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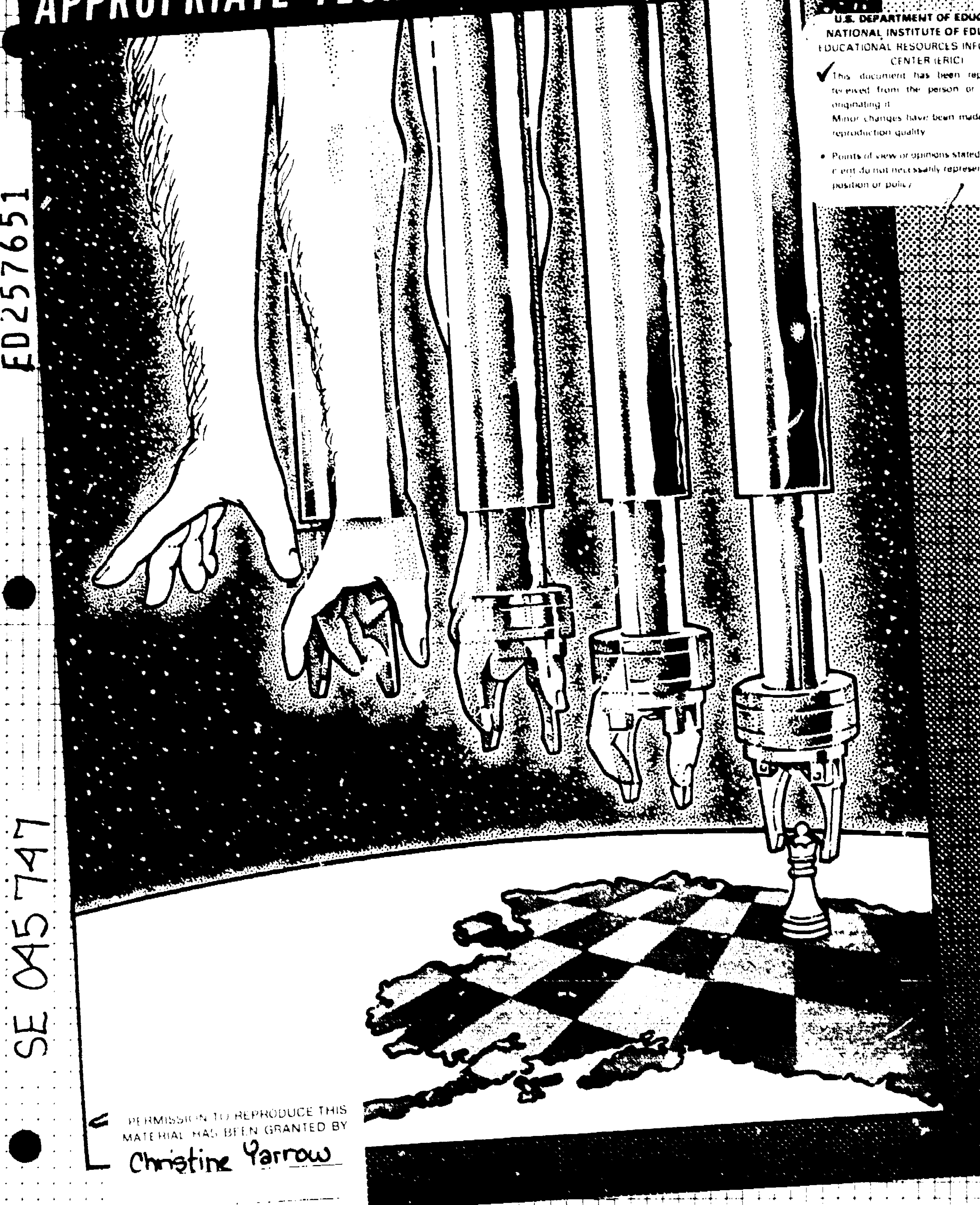
ABSTRACT

This course on appropriate technology is designed for use by individual high school students, small groups of students, or for classroom instruction. Course goals include developing a broad understanding of human technologies, examining the history of technology, reviewing and assessing various applications of appropriate technology, and discussing the effects of technologies on the past, present, and future of Alaska. The course consists of two chapters. The first chapter includes three lessons which focus on the historical beginnings of appropriate technology and the need for this technology in rich countries as well as in Alaska. The second chapter consists of 11 lessons which consider various aspects of the history of human technologies. Topic areas explored include agriculture, the birth of science, revolutions in energy, the growth of industry and trading, the industrial revolution, changes in society due to the industrial revolution, automation, the military industry, and the development of technology in Alaska. Lessons, which contain numerous illustrations, include reading material and (when applicable) a worksheet with cognitive and/or attitude questions for students to complete. (JN)

APPROPRIATE TECHNOLOGY FOR ALASKANS



PART I

APPROPRIATE TECHNOLOGY FOR ALASKANS

AN ELECTIVE COURSE
FOR
HIGH SCHOOL STUDENTS

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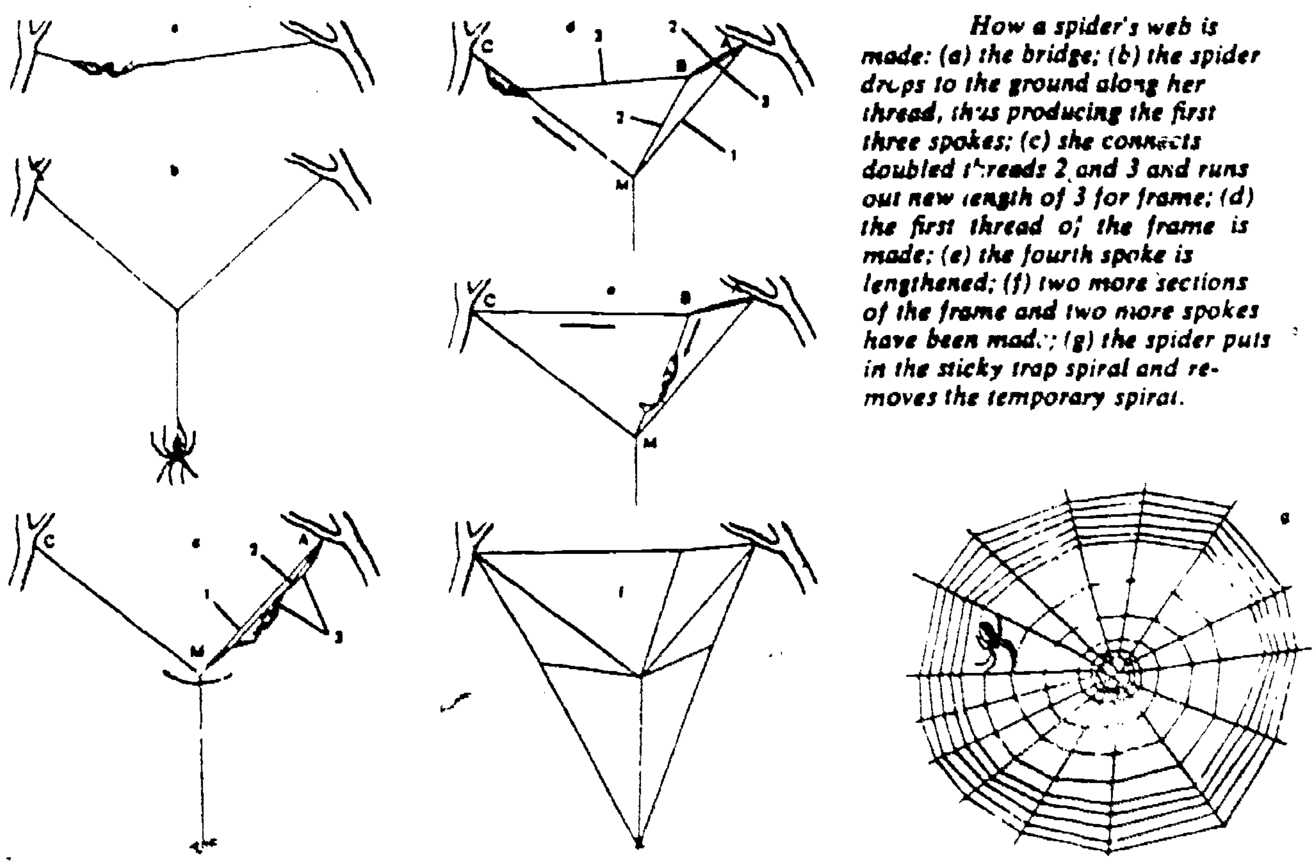
INTRODUCTION

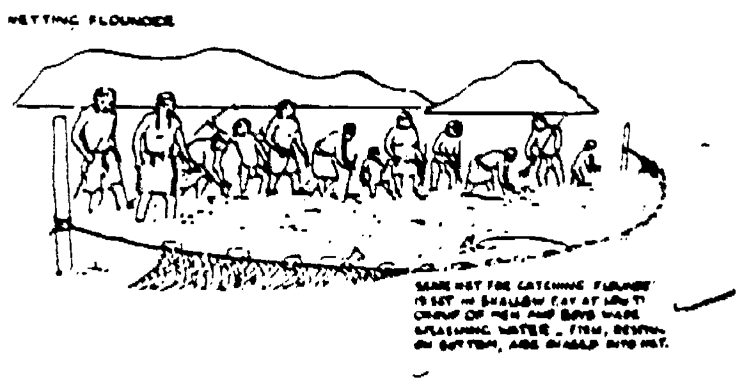
COURSE GOALS

To help us understand the goals of this course, let us first look at a technology—nets for capturing food. For many millions of years, spiders have been spinning nets, which we call webs.



How a spider's web is made: (a) the bridge; (b) the spider drops to the ground along her thread, thus producing the first three spokes; (c) she connects doubled threads 2 and 3 and runs out new length of 3 for frame; (d) the first thread of the frame is made; (e) the fourth spoke is lengthened; (f) two more sections of the frame and two more spokes have been made; (g) the spider puts in the sticky trap spiral and removes the temporary spiral.

More recently, perhaps less than 20,000 years ago, a spectacular event took place on our planet. Humans invented fishing nets. People learned how to develop new technologies.



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Humans have become skilled inventors, teachers, and learners, constantly exploring new ideas and passing information from one generation to the next. We have gained the capacity to establish traditions and to experiment with cultural changes. Our technologies have played an important part in this evolution, and will continue to play a central role in all of our lives.

Centuries of Improved Fishing Nets

The first nets were made from the fibers of wild animals and plants.

The Tlingit and Haida Indians of southeast Alaska made use of the inner bark of cedar trees for making twine and rope. The bark of stinging nettle plants was used to make twine for nets by Indians who lived immediately south of Alaska. Europeans also used nettle fibers, and it is believed that the word "net" comes from the European word "nettle."

A major development of human civilization took place when people learned how to domesticate animals and plants. Fibers were cultivated, such as cotton which was used for centuries to make nets.

The next major event in fiber technology has taken place in more recent times—the manufacturing of synthetic fibers, such as nylon from oil. From 1951 to 1979, the world production of synthetics multiplied a hundred times.

World Use of Major Fibers, 1951-79

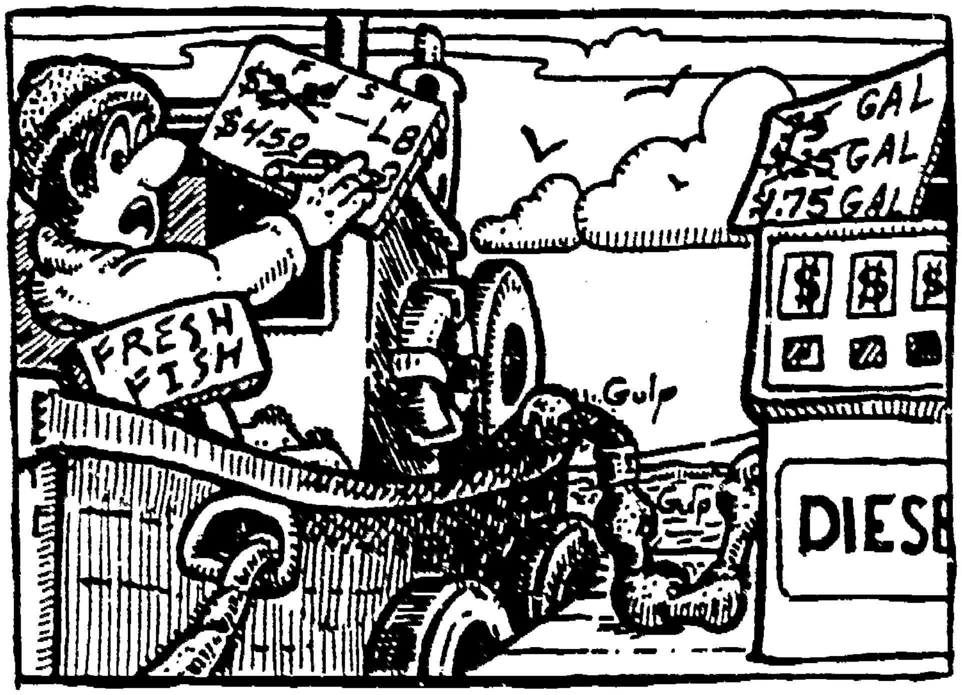
Year	All Fibers	Cotton	Wool	Rayon	Synthetics (Polyester, Acrylics, Nylon)	Synthetics as Share of Fibers Used
		(million metric tons)				(percent)
1951	10.8	7 8	1.1	1.8	1	1
1955	12.5	8.8	1.2	2.3	.3	2
1960	15.2	10.4	1.5	2.6	.7	5
1965	18.1	11.3	1.5	3.3	2.1	11
1970	21.8	12.1	1.6	3.4	4.7	22
1975	24.7	13 0	1.4	3.0	7.4	30
1979	29.1	13.8	1.5	3.4	10.4	36

Source: World Bank, U S Department of Agriculture, and Textile Economics Bureau.

Most of the fishing nets in Alaska today are made of nylon, which is strong, easy to work with, and does not rot.

Dependence on Non-Renewable Resources

Nylon fishing nets and diesel fuel, both made from oil, are very important for the Alaskan fishing industry. Yet our oil resources will not last forever. Synthetic materials and fuels can be made from wood, peat, coal, and other sources, all of which are abundant in Alaska—but there are some serious unsolved economic and environmental problems associated with these resources.

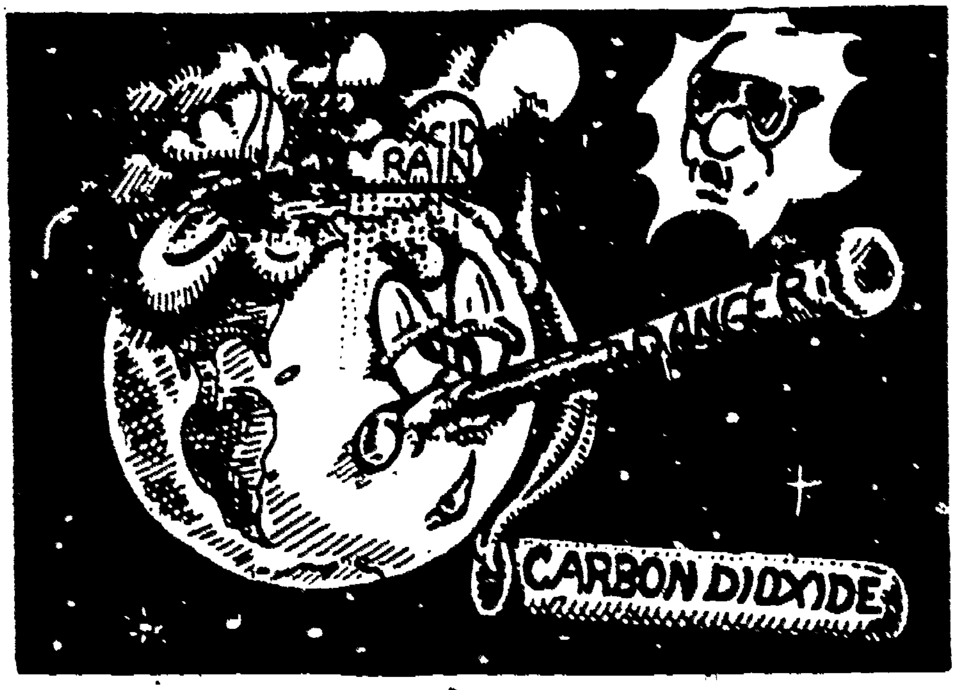


To solve problems such as these, a broad understanding of technology could be helpful. The development of this broad understanding is a central goal of this course.

A Small Planet

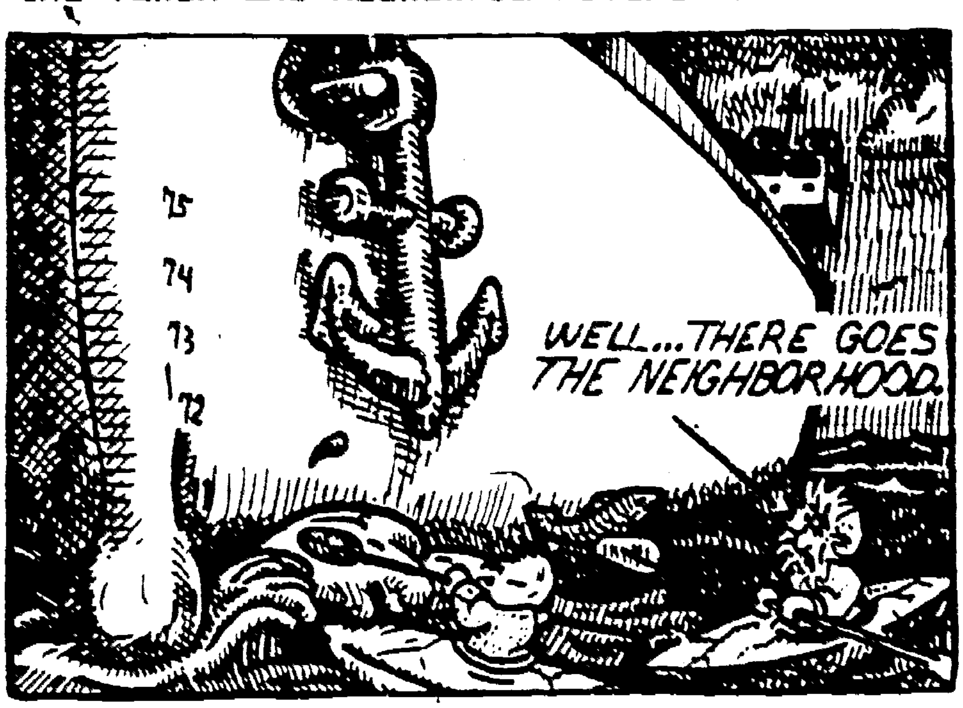
Modern technology has caused us all, whether we like it or not, to become citizens of a small planet. We can instantly communicate with people on the other side of the globe. We trade natural resources and manufactured products with distant countries.

The burning of fossil fuels is causing the amount of carbon dioxide in the atmosphere to increase, and also it is giving rise to acid rain



which falls upon the earth. Air pollution from Europe settles in the Arctic.

Decisions which are made in far-away countries can affect the amount of money which comes into Alaska. Eating habits of people in Japan and Europe can determine the profits of a person catching fish on the Yukon and Kuskokwim Rivers in Alaska.



This course will focus attention on these types of world balances. We will try to understand Alaska's position in the world. We will examine the fact that we have many natural resources, but rely on industries outside of Alaska for most of the manufactured goods—and food—which we use and consume in Alaska. We will also look at our strategic importance to the rest of the United States, due to the energy and mineral resources

which the national economy and military depend on. We will try to understand how events in the world could shape the future of Alaska, and we will discuss our responsibility to the rest of the world.

Developing, Choosing, and Using Technologies

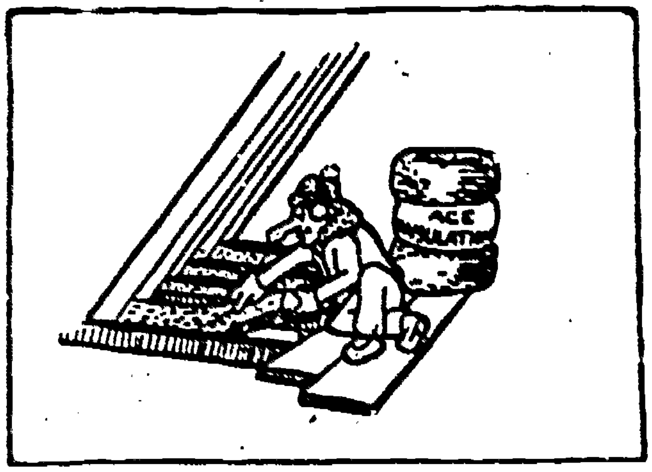
What are appropriate uses of technology? Discussion of this question is at the center of this course. Should technology rule our lives, or should technology be a tool which we carefully control? Should we allow the use of technologies, such as nuclear bombs, decide the future of our planet? Should some people benefit more than others from technology? How can we live according to our values and beliefs through the use of technology? There are no easy answers to these questions.

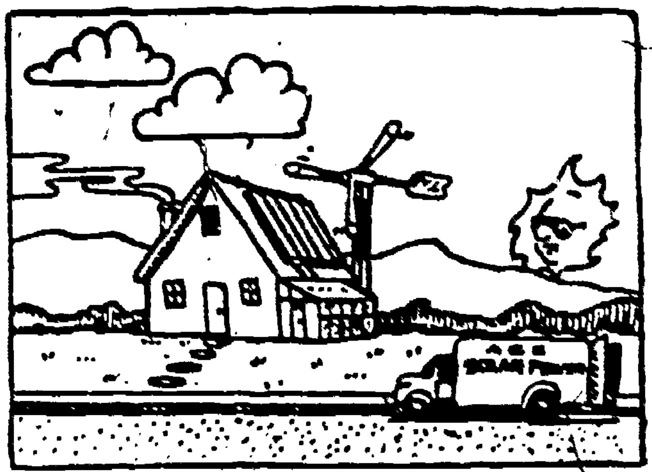
Whether for good or bad, the influence which human technologies have on human society and the natural world is difficult to ignore. There are many ways in which we develop, choose, and use technologies. One emerging philosophy which focuses attention on how technology should be directed is the philosophy of *appropriate technology*.

Appropriate Technology

The meaning of appropriate technology is nebulous. It is *not* easily defined in definite terms. At its foundation is the belief that technologies should be used to establish and perpetuate societies that are stable and which provide fulfilling lives for people--societies not prone to social disruptions and unfairness. To this end, a focus of appropriate technology is to establish technologies which are sustainable, based largely on local and renewable resources, and controlled by people who live in the regions where they are applied.

Such idealism must lead to pratical and realistic applications, or we will merely spin our wheels on the ice of hard fact and develop no forward momentum. The main goal of this course is to ask important questions about the future of Alaska and the world, to define problems facing humanity, to understand these problems, and to find solutions which are based on ideals--solutions which are practical and technically feasible.





One important goal should not be forgotten--to have some fun. We expect that the course will be exciting, and hopefully it will provoke some lively debate--an uninhibited exchange of ideas. There is a lot of new territory to explore, for teachers and students alike.

Some Themes

Several themes provide connecting threads throughout this course:

an international perspective

an historical perspective

a focus on Alaska

energy resources and uses

the growing influence of automation technologies (computers and robots)

Summary of Course Goals

Develop a broad understanding of human technologies.

Look at the history of technology, so as to have a better understanding of current technologies and potential future developments of technology.

Discuss the effects of technologoies on Alaska, past, present, and future.

Realize that we are citizens of an interdependent planet and that the uses of technologies can have far-reaching worldwide effects, both good and bad.

Discuss personal values, beliefs, and desires; and formulate opinions about how technologies should be used.

Develop the ability to be effective participants of our democratic society by learning how to influence decisions concerning the uses and development of technologies.

Ask questions about technology, even when there are no simple answers.

Develop a flexible definition of *appropriate technology* which can be used to help us choose and develop technologies.

Review and assess various applications of appropriate technology, both successes and failures.

Explore new ideas and have fun.

HOW TO USE THIS COURSE

This course is designed for use by individual students, small groups of students, or for classroom instruction. The course can be completed by a student independently, or it can form the basis for group or class activities. In either case, it is necessary for the person who grades the student's work to read the text of the lessons.

For students who work independently, the reading level is composed for seniors in high school who read at grade-level or beyond. Students who read on a lower level can complete this course with help from an instructor, which could be a parent or a school teacher.

Self-Paced or Group-Paced

A minimum of 25 hours (5 weeks of classroom instruction) is necessary to complete Part I, but students and/or teachers might choose to spend considerably longer working on this part of the course. There are many points raised which need careful consideration, for which classroom-discussion would be an especially helpful addition. Students are encouraged to work at a pace that they find comfortable and productive.

Grading

Pass-fail grading is strongly urged, especially due to the fact that the expression of students' personal opinions is an important feature of this course. Also, it is the sincere wish of the authors that students focus attention on the content and purpose of the course, not because they feel coerced by the prospect of a grade, but because they find an interest in the information presented and the issues raised.

Record-Keeping/Progress Chart

Students are asked to use the progress chart on the following page to keep an accurate record of work completed. If additional work is completed, other than that requested on worksheets, list these activities in the space provided. Here are some examples of additional work: classroom discussion, the reading of supplementary materials, completing addtional writing assignments, library research, writing or presenting a report, experimentation, etc.

PROGRESS CHART

LESSON NUMBER		DATE STARTED	DATE COMPLETED
CHAPTER 1	#1		
	#2		
	#3		
CHAPTER 2	#1		
	#2		
	#3		
	#4		
	#5		
	#6		
	#7		
	#8		
	#9		
	#10		
	#11		
ADDITIONAL WORK:			

CHAPTER 1

APPROPRIATE TECHNOLOGY

When the phrase *appropriate technology* is heard, it is easy to picture a solar-heated home, a wood stove, a windmill, or a compost pile.

Appropriate technology is an *approach* used for the development of technologies. This approach is being applied more and more throughout the world to solve problems and to avoid problems which are looming on the horizon.

The purpose of this chapter is to acquaint you with the early beginnings of appropriate technology, and with some of its basic meanings.

APPROPRIATE TECHNOLOGY

LESSON 1

HISTORICAL BEGINNINGS OF APPROPRIATE TECHNOLOGY

We have not inherited the earth from our fathers, we are borrowing it from our children.

Lester R. Brown
Worldwatch Institute

INTRODUCTION

We start this course with a problem. The problem is to define *appropriate technology*.

In this lesson we take a quick look at some events which have taken place during the twentieth century. These events provided fertile ground in which the seeds of *appropriate technology* germinated.

We then look at the historical beginnings of *appropriate technology* to better understand what it is.

A central theme of this course is ***technology***. Technology can be defined in many ways. Simply, it can be considered to be tools and the uses of tools. Language is a technology. So is a fishing boat.

OUR CENTURY

We live in an exciting, tumultuous

century. It is a century during which many new technologies have been developed, a century of great social upheavals, of changes in human society which are not yet understood or even realized. Here are some features of our century that technology has helped shape:

Radio, TV, and communication satellites bring daily news of the world into people's living rooms.

Automobiles, trucks, snowmobiles, bush planes, jets, and rockets propel people and goods, down the street and to the moon.

Biologists are unravelling life atom by atom, and looking at cells with microscopes which use electrons instead of light. DNA, the stored information in plants and animals, is being uncoded and put together in new ways to create new forms of life.

Doctors and medical scientists transplant hearts and kidneys from one person to the next, and join human sperm and eggs in test-tubes. Human organs are being replaced by machines which surgeons can implant into our bodies.

Agricultural scientists have developed high-yielding crops for farmers who can afford tractors, chemical fertilizers, and chemical pesticides. Now agricultural scientists are attacking the problems of farmers who can't afford, or choose not to use these expensive products.

Computers, artificial intelligence, and robots have leaped from science fiction into reality. Computers and robots are rapidly replacing many workers, ushering in an era that is just beginning.

Time, space, matter, and energy have been interpreted by Albert Einstein, laying the foundation for new philosophies about reality and paving the way for harnessing the power that fuels the sun and other stars--atomic power. The enormous potential of atomic power as an energy source for humans has been coupled with the fear of radiation, power plant melt-downs, and the fear of a nuclear war in which all life on the planet could be destroyed, possibly in a single day.

It is a century colored by science and technology. But it is also a century in which powerful theories of science and mathematics seem to say that there might be a limit to how much people can learn by using scientific methods.

World population has tripled, from about 1.3 billion in 1900 to about 4.4 billion in 1980. A huge strain on the world's natural resources and governments has resulted, while population continues to increase.

After increasing for many years, the total yearly catch of fish in the world has levelled off, and even fallen during some years. A natural limit of the oceans has been reached, but new technologies hold promise for increasing the world fish-catch dramatically.

Highly industrialized countries have become dependent on energy, food, and mineral resources from less developed countries and from places such as Alaska. This condition has had a major influence on world and local economies and politics. This has especially been true for Alaska.

The burning of coal, oil, and natural gas is dramatically increasing the amount of carbon dioxide and other chemicals in the

atmosphere. Fears of rising world temperatures and acid rains have resulted in international tensions and a search for solutions.

While one of every eight people on the Earth is malnourished, some people are extremely wasteful. In some countries it is not uncommon to find people dying from starvation amidst plentiful food resources which are being exported to other countries. Mass starvation has killed many people during this century, not because of inadequate technology or lack of food, but because of decisions made by people.

There have been two world wars of a scale never before known on our planet, making use of technologies for killing which are more effective than weapons of any other century: fighter planes, bombers, helicopters, tanks, gas chambers, chemical and biological weapons, exotic torturing devices, and the atomic bomb.

Six million Jews were tortured and killed, as part of an attempt to exterminate their whole race.

Untold millions of Russians were killed for the purpose of establishing a new form of government meant to bring equality to the world.

This century has seen the production of weaponry become the world's largest industry.

Powerful democratic countries, in the name of freedom, have interfered with democratic elections in less powerful countries, such as Vietnam and Chile.

Powerful non-democratic countries, in the name of equality, continue to discourage freedom of speech and the freedom of workers to organize in countries such as Czechoslovakia and Poland.

Often neglected because of its current lack of power, the United Nations, a development of our century, is the first substantial attempt to form a worldwide organization of all nations. Indeed, this century might be remembered more for the beginning of an emerging cooperative world, than for the international problems which surround us today.

Clearly this has been a dramatic century so far. And clearly, technologies have played a major role. Let's now look at a short biography of a man intimately involved with development of technologies for our world.

E. F. SCHUMACHER

To understand the meaning of *appropriate technology*, it is helpful to understand its beginnings. To understand it beginnings it is helpful to know something about the people involved.

It is rare, if ever, that one person is responsible for starting trends. It is not rare, though, for an individual to pull together many people who share similar ideas and experiences, to focus trends, and to become a folk hero for a surfacing culture. Such has been the role of Ernst Friedrich (Fritz) Schumacher, for the "culture" of *appropriate technology*.

E. F. Schumacher's life led him

remarkably close to some of the important events of our century. Born in the university town of Bonn, Germany, he had the boyhood experience of growing up during World War I, in which his country was defeated. His father was a professor of economics and politics, so his family-life did not leave him lacking in at least a basic understanding of the wartime events around him.

After studying at German Universities in Bonn and Berlin, Schumacher went to Oxford University in England. These three centers of learning have been, for centuries, places where many powerful leaders and scientists have studied. The centuries-old "living history" found in these cities can have a deep-felt influence on university students.

After being immersed in this European sense of history, Schumacher had the opportunity to experience some of the pioneering freshness of America. He studied at Columbia University in New York, where his father had been a visiting professor thirty years before.

In 1934 Schumacher returned to Germany to begin a career in an import-export business. This was the year that Adolph Hitler became the chancellor of Germany. As the Nazis increased their power and influence, Schumacher, like so many other German intellectuals, left his homeland once more.

In 1937, newly married and at the age of twenty-six, he arrived once again in England, and soon started a company that sold electric vehicles. This business was short-lived, however, because World War II broke out. German citizens living in England were suspected of being spies, so the English government put them in ***internment***, a kind of imprisonment. (In the United States, the Japanese were similarly interned during World War II.)

As fate would have it, Schumacher spent three years of his internment as a farm laborer. He mentioned this experience several times later in his life, claiming that "this was my main university." For a German intellectual businessman, working the land with the strength of his muscles was a very new experience.

Following his internment, Schumacher worked as a newspaper reporter for the London *Times*, as an economist designing a welfare system for England, and as a member of the United States Strategic Bombing Survey. In 1946 he joined the British Control Commission in Germany, where he spent four years as an economic adviser.

The main part of Schumacher's working life was spent as an economist with the British National Coal Board, from 1950 to 1970. In 1955 he spent three months in Burma as a United Nations economic adviser to the local government. His experiences in this and other Asian countries prompted his concern for poor people. He later said, "I am interested in the poor. I've always found that the rich can look after themselves. They don't need me."

INTERMEDIATE TECHNOLOGY

Following a visit to India in 1963 Schumacher coined the term *intermediate technology*. Three years later he founded the Intermediate Technology Development Group, a group dedicated to improving conditions of life for poor people in poor countries.

Economic development for poor countries had until this time usually focused on the introduction of the expensive technologies usually found in industrialized countries such as England, Germany, or the United States.

"Economic development" is a term which means the creation of farms, industries, businesses, and jobs.

Schumacher had an idea. After observing that the introduction of modern technologies did not always bring benefits to poor people, he described a new type of economic development. It was based on a technology "more productive than the [local] technology but immensely cheaper than the...technology of modern industry."

An important feature of *intermediate technology* is what Schumacher called "Buddhist Economics." To Schumacher, work is of spiritual importance, an opportunity for people to develop spiritually. Human labor is not *only* for the purpose of producing goods and services. Schumacher noted that most modern economists consider "work as little more than a necessary evil." To the employer, work is "simply an item of cost, to be reduced to a minimum if it cannot be eliminated altogether, say, by automation."

It is important to realize that *intermediate technology* was founded on the basis of spiritual values, as well as practical economic thinking. For Schumacher, this approach was as much Christian as Buddhist.

In order to be successful, according to Schumacher, *intermediate technology* should have four characteristics. First, it should create employment in the rural areas to reduce the migration of people to cities where there often were no jobs to be had. Second, this technology should rely more on local labor than expensive machinery and resources. Third, *intermediate technologies* should be simple enough for local people to make and repair for themselves. Fourth, this technology should be used mainly for producing goods for local use.

Two Ways to Build an Irrigation System

Let us consider an application of technology in a typical situation faced by farmers in many poor countries--the building of an irrigation system to increase food production.

The "modern" approach often depends on expensive machinery, such as bulldozers. This is a ***capital-intensive*** approach. "Capital" is wealth which is used or available for use in the production of more wealth. The bulldozer, in this case, is the capital. The *intermediate technology* approach is often ***labor-intensive***, meaning that instead of the capital (the bulldozer), human labor is used.

When the bulldozer is used to dig canals for the irrigation system, few jobs or experience are provided for local farmers. Following the building of the canals, if tractors are introduced, many of the farmers might have no jobs at all. Frequently they migrate to cities, looking for employment opportunities which do not exist. This sequence of events is quite common.

Now consider an *intermediate technology* approach. First, it is realized that many skills are needed to establish an irrigation system that will benefit all the farmers. It is decided that it would be better to develop these skills and use local resources, than to import a lot of materials and "experts." A small-scale metal shop is set up to make hoes, shovels, and wheel barrows. A plumbing business, based on pipes made from bamboo, is also set up. Farmers form a ***cooperative***--an organization for helping each other--so that they can build and maintain an irrigation system together.

After successfully completing the

project, the community has an improved food-producing system. More importantly, many skills have been learned. There are now two shops which can make tools. The skills needed to run these ***small businesses*** are valuable, and can form the basis for starting new businesses. The farmers now have an irrigation system which they know how to repair themselves, and they have learned how to better help each other. The community as a whole is better prepared for more development. Everyone is employed. The new skills have helped the community develop self-confidence and self-reliance.

This make-believe story of applying *intermediate technology* is in some ways very true to life. But the world is rarely this simple. In later lessons we will look at examples of failures and successes of the *intermediate technology* approach, and try to learn from them.

INTERMEDIATE BECOMES APPROPRIATE TECHNOLOGY

How and when the term *appropriate technology* first appeared is uncertain. The fact is that it did. We use it in this course because it has become a way to focus the attention and efforts of many people and groups working to make the world a better place for all of us.

The word *appropriate* means "suitable for a particular person, condition, occasion, or place." It has the sense of "that which is right or good," as compared with "inappropriate," which has the sense of "wrongness." Calling something *appropriate technology* strongly implies that there are *inappropriate* technologies.

The term itself might have first surfaced at a meeting of Schumacher's intermediate technology group in 1968. The meeting had the long title of "Conference on the Further Development

in the United Kingdom of Appropriate Technologies for, and Their Communication to, Developing Countries."

Of the more than one hundred participants at the meeting, there were representatives of British industry, the British Ministry of Overseas Development, the United Nations Economic Commission for Africa, the International Labor Organization, and the very influential Organization for Economic Cooperation and Development.

It was at this meeting that the term *appropriate technology* was suggested as a replacement for *intermediate technology*, on the grounds that "intermediate" sounded as if it really meant "second best." The new name stuck. Five years later, Schumacher's group changed the name of their newsletter from the *IT Bulletin* to *Appropriate Technology Journal*.

Small Is Beautiful

The publishing in 1973 of Schumacher's book, *Small Is Beautiful: A Study of Economics As If People Mattered*, brought world recognition to the man and his ideas. The term *appropriate technology* soon became commonly used by many people involved in economic development.

The Governor of California, Jerry Brown, took a keen interest in Schumacher's ideas, establishing an Office of Appropriate Technology in 1976.

President Jimmy Carter met with Schumacher. While Carter was still president, the National Center for Appropriate Technology was funded as an arm of the federal government to meet some of the needs of poor people in the United States.

The United States Department of Energy, also under Carter, started the Appropriate Technology Small Grants Program. This program provided money to people who wanted to develop appropriate technologies, with an emphasis on energy-related projects.

Appropriate Technology for Alaskans

This high school course was written as part of a project funded by the Appropriate Technology Small Grants Program and the Alaska Division of Energy and Power Development.

In Alaska there has been a great deal of interest in *appropriate technology*. The state government has provided money to people throughout Alaska who are working on appropriate technology projects. Later in this course you will have a chance to learn about many of these projects.

SUMMARY

Our world is constantly changing. This century has witnessed events that have shaken the foundations of powerful ideas and mighty governments.

As the world changes, so do the ways in which we think and the ways in which we act.

Appropriate technology is a germinating seed, fertilized and watered by the events of the world. In the next lesson we will look closer at some of its meanings and at some recent changes.

COMPLETE THE FOLLOWING WORKSHEET

APPROPRIATE TECHNOLOGY

WORKSHEET

Answer the following questions in the space provided.

1) On page 1-1 a simple definition of ***technology*** was presented. Language and a fishing boat were both identified as being technologies. What do they have in common?

2) Would you consider a spider web to be a technology? Why or why not?

3) Were you aware of all the events and technologies listed in **OUR CENTURY**?

4) Which, if any, surprised you? Why?

5) What important events and technological developments might be added to the list before the year 2000? Use your imagination!

6) In this lesson an *historical approach* has been used to help you understand *appropriate technology*. Do you find this approach beneficial? Why or why not?

7) How do you think E. F. Schumacher's personal life history influenced his ideas and actions?

8) Much of the work of Schumacher's Intermediate Technology Development Group has been directed towards countries where

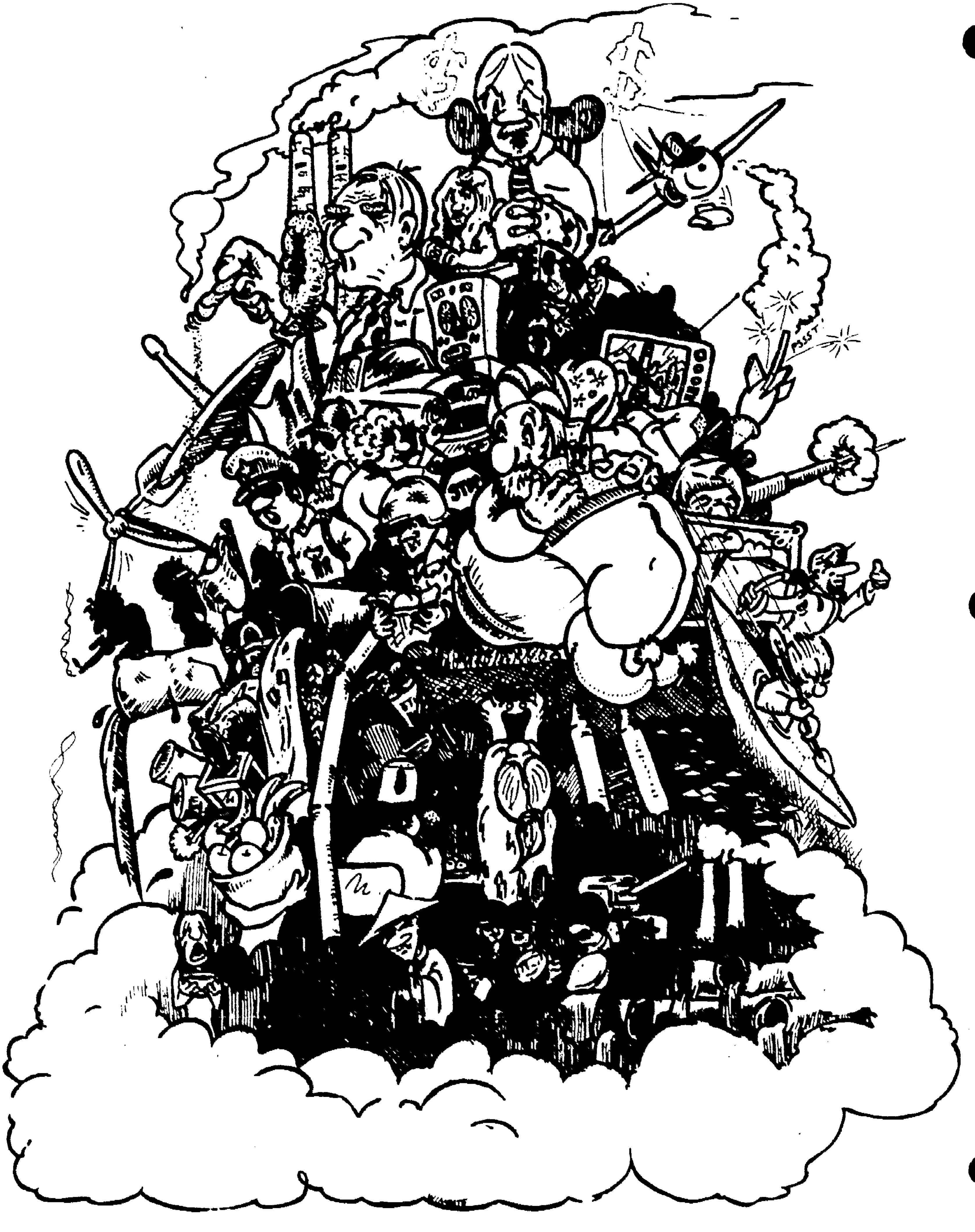
people lack basic necessities of life, such as food, clothing, and shelter. Based on what you learned in this lesson and what you already knew, do you think that the *appropriate technology* approach to economic development is worthwhile? Why or why not?

9) What do *you* believe are the important benefits gained by working? If you had the choice, would you have machines do all the work which is normally done by humans? Why or why not?

10) In the next lesson you will learn about why *appropriate technology* has been adopted by many people to solve problems faced in rich industrialized countries, such as the United States. Before reading the next lesson, can you guess why?

APPROPRIATE TECHNOLOGY

LESSON 2


PSSST!

LESSON 2

APPROPRIATE TECHNOLOGY: FOR RICH COUNTRIES? AND ALASKA?

> *Because I see so many weak ones trodden down, I greatly doubt the sincerity of much that is called progress and civilization. I do believe in civilization, but only in the kind that is founded on real humanity. That which costs human life I think cruel, and I do not respect it.*
>
> **Vincent van Gogh**
> Dutch painter

INTRODUCTION

Today's world is sharply divided into rich and poor countries. Consider the table on the next page, which presents facts from a 1981 World Bank report.

Average yearly incomes per person are calculated by dividing the ***gross national product*** of a country by the number of people who live in that country.

Gross national product (GNP) is the *total* money-value assigned to *all* the goods and services produced by a country in one year. This includes the value of all the products of farms, factories, individual craftspeople (such as carpenters), and the value of all services (by hairdressers, doctors, etc.). In other words, GNP is a way to

measure the result of all the work done in a country during one year.

In the early 1980's, the United States had a population of about 230 million people, with an average yearly income of $10,630--based on GNP per person.

Alaskans, who numbered less than half a million, had an average yearly income of $13,763 in 1981--based on actual personal income.

POOR COUNTRIES		
VERY LOW-INCOME (36 countries)	2.3 billion people	$230 average yearly income per person *
LOW-INCOME (60 countries)	1 billion people	$1420 average yearly income per person *
RICH COUNTRIES		
HIGH-INCOME (28 countries)	1 billion people	$7960 average yearly income per person *

*calculated in 1979 U.S. dollars

The approximately 150 countries of the world are members of a very large and complex human society. To help us understand this complex society, it is helpful to make simple generalizations about the world. For the purposes of this lesson, we make a simple generalization by labelling countries as either *rich* or *poor*. ("Poor countries" are often referred to by several other labels. Three common ones are:

underdeveloped, *less developed*, and *Third World*.)

Simple generalizations can be helpful, but they can also confuse issues. By using average yearly incomes for determining whether a country is "poor" or "rich", we ignore other important considerations.

One important consideration which we have ignored is the fact that *average* income tells us nothing about how income is used and shared *within* a country. Another consideration which we ignore is the *quality of life* within a country. Income is not always a good measure of whether or not people are comfortable or satisfied with their lives.

If we keep these problems in the back of our minds, then the generalizations about rich and poor countries can be helpful.

Some Guidance For Studying This Lesson

In the last lesson we attempted to trace some of the historical beginnings of appropriate technology. We learned that it was originally developed as a tool for helping poor people in poor countries.

A crisis has been developing for people who live in rich countries. This crisis has given new meaning to appropriate technology.

In this lesson we examine the crisis of the rich countries, and then try to understand why appropriate technology is being called upon to help provide solutions. We then look briefly at some values and needs of Alaskans.

The reading material for this lesson is fairly long and difficult. There is no worksheet for you to complete. *You will need to understand*

the material presented in this lesson to complete the worksheet of the next lesson.

> *Over the past year the vitality of U.S. industry has emerged as a major new public policy issue. After decades--literally whole lifetimes for most Americans--of dominance in the world's marketplaces, we suddenly find our industrial leadership and, it seems, our future challenged by aggressive new foreign competition.*
>
> **George A. Keyworth, II**
> President's Science Advisor
> Science, June 10, 1983

CRISIS IN THE RICH INDUSTRIALIZED COUNTRIES:
A New Meaning for Appropriate Technology

Most of the rich countries have established their wealth by means of very large industries which use large amounts of raw materials and energy. These rich nations are often referred to as the ***industrialized countries.***

A few countries have become rich by exporting raw materials, especially energy resources, to the industrialized countries. (This is also the way in which Alaska has increased its wealth.)

There are now many industrialized countries in the world, including Japan and the U.S.S.R. (Russia). For the purposes of the following discussion, we will consider only the United States and Europe. Much of what is discussed applies to many of the other rich countries.

A Loss of Confidence

After World War II there was a general sense of well-being for most

Americans. The United States had been considered the hero in the fight against a terrible evil--Adolph Hitler. The U.S. also was very helpful in rebuilding a heavily bombed Europe. Europeans made an amazing recovery and soon established very productive industries.

For Americans, there was a well-deserved sense of accomplishment. It was the time of the "American Dream." Business flourished. Many women who had worked at various jobs during the war took up occupations of domestic life, as housewives and mothers.

There seemed to be opportunities for everyone. Or so it seemed. The relatively quiet 1950's suddenly became a distant memory as the Civil Rights Movement shook the nation. Black people and other minorities rose to ask for rights that were guaranteed to them in the U.S. Constitution. In a time of national prosperity, their poverty and second-class citizenship was a sharp contrast. It was a painful, yet exhilarating awakening for the nation.

In 1954 a very important battle took place in a town of northwestern Vietnam, Dien Bien Phu. In this battle the Vietminh forces won a decisive victory over the French army. This battle was one of a long series of events which eventually pulled the United States into a war in Vietnam.

The Vietnam War further pulled apart the people in the United States and Europe. With the tragedy of more than 50,000 dead American soldiers and countless other people, few Americans and Europeans had a clear sense of what their involvement had really meant.

While people were being killed in Vietnam, a concern for natural environments was growing. The *environmental movement* became a cry for

saving natural environments and health, which were seen as victims of our technologies.

Factories, cars, and even farming can cause extensive pollution. Large-scale industrial development is founded on the use of massive amounts of raw materials, often collected from remote wilderness areas. A public outcry to save some of these areas was heard throughout the United States and Europe.

The illegal acts of a president, the so-called Watergate Affair, further disturbed many already disillusioned citizens--ending with the first resignation of a U.S. president and prison terms for some of this country's top government officials.

The clear sense of confidence felt after World War II was quickly being eroded.

Sharing of Power/Limits to Growth

ing World War II the United Stat had become the leading power in the world. It had demonstrated the strength of its industries, the might of its military forces, and it had successfully organized European and American scientists to develop the first atomic bomb.

Europeans had been divided, but as already mentioned, they were quick to make up for lost time.

The world was changing. World power had for decades been shared by only a few countries, but was now spreading rapidly throughout the world. The U.S.S.R., which had been one of the poorest nations in Eurasia for a thousand years, was beginning to become a power to be watched. Many of the colonies of European countries were

becoming independent.

Oil Crisis

In 1973, the year in which E.F. Schumacher's book, *Small Is Beautiful*, was published, ***OPEC*** imposed an oil ***embargo*** on Europe and the United States. The ***oil crisis*** had started.

OPEC, short for Organization of Petroleum Exporting Countries, is an organization of several oil-producing nations. Together, these countries decided that they were not getting as much money as they should for their oil. To impose an embargo simply means to refuse to sell a product. In this case the product was oil. Later in this course we will take a closer look at how OPEC first became organized and what they chose to do.

Europeans and Americans, who had come to depend heavily on imported oil, were shocked by the embargo. Oil prices rose rapidly. Many powerful industries suddenly looked like Goliaths facing David. The economies of Europe and the United States trembled.

Economic Recession

While this lesson is being written, the winter of 1982, the United States is struggling with a 10.4% unemployment rate. People are comparing the 1980's ***recession*** to the Great Depression of the 1930's. A recession is a period of time when the economy of a country slows down.

The dramatic increase in the price of oil, which followed OPEC's oil embargo, was at least one of the causes of the recession.

Alaska's experience during these times followed closely that of the OPEC

nations. One result of the crisis was the additional importance given to the building of the Transalaska Pipeline. In fact, then President Gerald Ford declared that the pipeline was a national defense necessity.

Large increases in the price paid for oil meant big increases in money coming into Alaska. During the recession, Alaskans learned the meaning of sudden economic prosperity. As we will see later, pipeline construction was the beginning of a new era for Alaska.

As you will also learn later, the ***international economic crisis***, which resulted from the recession, greatly reduced the income of the OPEC nations.....and of Alaska.

International Economic Crisis

The 1980's recession affected all of the rich countries. It became the tornado at the center of an international economic crisis.

The crisis also affected many of the poor countries, especially those who had borrowed large sums of money for economic development. With many countries having difficulty in paying their debts, there has been a concern that the international banking system could collapse.

Much of the economic expansion of the rich nations has become dependent on markets in the poor countries. Meanwhile, competition for markets has become more vigorous, as more countries industrialize.

Industries depend on the selling of products. To sell products, there must be a flow of money. When many people are unemployed, as during the 1980's recession, there is usually less money

available for buying products. Consequently, industries slow down and more people become unemployed.

Recessions are not uncommon. The 1980's recession, though, was worse than most have been in the *recent* past.

Usually, during a recession, prices drop, which stimulates buying. Increased buying eventually necessitates an increase of industrial production. The increase of production stimulates the creation of jobs. A new cycle of economic recovery can begin. Economic growth can take place.

Limits to Growth

A cycle of economic recovery will probably follow the 1980's recession. But times have changed. The diminished availability of inexpensive natural resources is a concern not easily avoided. New economic strategies might be necessary.

It is important to realize that Europe and the United States, who had experienced rapid development of their industries, suddenly were faced with a shortage of resources. They were now competing with many countries for ***limited resources***. Limits of energy, materials, and political power became serious concerns.

The idea of ***limits to growth*** was heard as a quiet murmor beneath the roar of mighty industries. "Limits to growth" often refers to limits of economic growth.

Alaska has become nationally and internationally important as a source of the raw materials for industry.

TO SUMMARIZE

After World War II there was a period of rapid economic growth in the United States and Europe. This was a time for healing wounds. The industrial power established during the war was used to greatly expand standards of living. In the United States big cars became a common sight and many people were able to buy their own homes.

The quiet was not long-lived. Social turmoil in the United States was quickly followed by environmental problems and the oil crisis. These problems also struck harshly at many other industrialized countries. The natural resources on which we depend were being depleted, and the economic dominance we had grown accustomed to was being shared more and more with other countries.

Economic troubles were soon to follow. Unemployment became a major problem. An international economic crisis developed. Recovery seems likely, but the uncertain availability of raw materials and energy could slow the process.

To the above must be added another source of tension. Since World War II there has been a massive build-up of military weapons, both nuclear and conventional. The possibility of widespread destruction has increased, and for many people in the world, warfare is a harsh reality.

As you will learn later in this course, both rich countries and poor countries have sometimes become dependent on the production of weapons as an important source of income.

APPROPRIATE TECHNOLOGY: Solutions for Problems? For Both Rich and Poor Nations?

So, what does appropriate technology have to offer?

The emphasis of appropriate technology is nonviolence, respect between people and countries, respect for natural environments, and a striving for self-reliance so that people do not depend on the resources which rightfully should be used by other people. It is often described as "thinking globally and acting locally." Simple!

To think that appropriate technology can be simply put into action, or that it is the only answer for the problems of the world is *expecting too much*! But appropriate technology should be given serious consideration, because it is one of the many forces in the world which are working for the benefit of all people.

A Social Movement Called a Technology

Let's take a closer look at what is meant by appropriate technology, before trying to see if it holds any potential for providing some solutions for problems of the world.

As mentioned in the first lesson, it is rare that one person is responsible for establishing trends. E. F. Schumacher was by no means the only parent of appropriate technology. There have been many people involved, and as a result there are many definitions of appropriate technology.

We started this course with a list of some features of our century. These features include some frightening events and some amazing achievements. One thing is for certain. We live in a century colored by our technologies.

Some would say that our century is *dominated* by our technologies. We are a people surrounded by our machines.

Appropriate technology is more of a ***social movement*** than a technology. A social movement can be described as the ideas and activities of a group of people working to achieve specific goals.

The social movement of appropriate technology directs much of its efforts at avoiding and solving many of the problems already presented in this lesson.

No Single Definition

Appropriate technology has come to have *very different meanings* for various people. Usually when it is mentioned, *one or more* of the following things is meant: a theory about economic development, an approach for the development of technologies, or a type of technology. In this course we will be considering all of these together.

The following list includes some important features that *many* definitions of appropriate technology typically include.

Appropriate technology:

*focuses attention on worldwide relationships to help us understand how we need to act in our own communities.

*stresses uses of technology which give people the freedom to choose how they want to live, emphasizing the use of locally available labor and natural resources.

*seeks to use technologies which increase the number of satisfying

jobs, while avoiding technolgoies which put people out of work. Work should involve: the learning of life-sustaining skills, increased self-reliance, and enhance the ability to be ***innovative*** (having the ability to find or develop new ideas, often for the purpose of solving problems).

*attempts to develop technologies and economic systems which are ***sustainable***. A sustainable technology or economic system is one which can be continuously replenished. [Heating with wood can be a sustainable technology, while oil-heating can not. When supplies of oil run out, it will not be easy to replenish them. It took millions of years for the oil to collect in the Earth's crust. Wood, *wisely used*, can be replenished yearly.]

*sees the necessity of using technologies in such a way as to avoid violent confrontations. Technologies which increase self-reliance are helpful for achieving this goal.

*understands the value of caring for natural environments.

*realizes that technologies should be adapted to differing regional needs, individual situations, and people's chosen lifestyles.

Now let's see how these various aspects of appropriate technology are applied.

Competition for Limited Resources

The dependence of industrialized countries on massive amounts of imported materials and energy has led to many problems.

Industries which contribute to the destruction of the resources on which they depend, can not last forever. The emphasis of appropriate technology on sustainable industries is very important.

Appropriate technology stresses the use of ***renewable resources***. Renewable resources are those which can be continuously replaced after being used, such as wood or sunlight. The use of locally available resources, whenever possible, could contribute to long-term security. Avoiding waste, using resources efficiently, making durable products, and the recycling of materials are all part of an appropriate technology approach.

A frequently presented example of appropriate technology is the use of solar energy as a source of power. Solar energy is a locally available, renewable resource. It is limited, as all resources are, so must be used efficiently. The technologies used to collect solar energy can be made of durable and recycled materials.

Pollution and Destruction of Natural Environments

Concern for environments, both natural and human, is important. Human environments do not exist separately from the so-called natural environments. Our lives are entirely dependent on many natural systems, including the ones in which our food grows and the ones which produce the oxygen we breathe.

An emphasis of appropriate technology is the use of technologies which minimize harm to the environment. Our previous example, the use of solar energy, fits well here also. By using solar energy we can avoid some of the pollution problems associated with

burning fossil fuels and wood.

Unemployment

Let's continue with our solar energy example. In a study prepared by Colin Norman in 1978, for the Worldwatch Institute, nuclear energy and solar energy are compared:

> A projection of the employment impact of an aggressive solar energy program in California indicated that some 377,000 jobs a year could be created in the [1980's]. That level of job creation would be sufficient to halve California's present unemployment total. Another study found that while construction and operation of California's controversial Sundesert nuclear plant would provide about 36,300 jobs,...[A solar program which would produce the same amount of energy] could create about 241,000 jobs. Solar technologies, moreover, create jobs in the areas where people live, while construction of giant power plants requires work crews to be gathered in one location, disrupting the life of local communities.

Appropriate technologies, such as solar energy, can help alleviate unemployment problems. Added benefits are the creation of satisfying jobs, increased skills and awareness, and community self-reliance.

Avoiding Violence

What are the motives for violence? At least partially, the competition for limited resources might be to blame.

Building a society based on the security of self-reliance might help to alleviate confrontations. This does not mean that nations should isolate themselves. There is a lot to be learned from each other, and trade between countries can be beneficial for everyone, if done with care.

Looking once more at solar technologies, we can see that independence from uncertain supplies of oil could reduce tensions which lead to crises.

There is another benefit from using solar energy or other locally available renewable energies. By doing so, we can eliminate the need for building nuclear power plants. Some of the byproducts of nuclear power plants can be used to make atomic bombs. To protect these materials, very strong and costly police systems must be maintained.

APPROPRIATE TECHNOLOGY FOR ALASKANS

Alaska is not, as many people would like to believe, separate from the rest of the world. In fact, because of our richness in natural resources, we have become a focus of world attention.

Lots of Natural Resources—Little Manufacturing

The Alaskan economy is based on the export of natural resources and the import of manufactured products. Look around you. What do you see that was *made in Alaska*? How is money earned to buy products which are imported?

Our economy has become tightly linked to the international economy. During the international economic crisis which was described in this lesson, the income for the Alaska state

government was cut in half because of a drop in oil prices. (The state government is the largest single employer in Alaska--about 16,000 workers in 1981.)

Alaskan Values/Alaskan Lifestyles

Alaska is a vast territory, with many diverse cultures. There is not a single set of values which are shared by all Alaskans.

A common value, though, is placed on independence and self-reliance. Another is pride in our magnificent state, for its beauty, resources, and the warmth of the people.

Many Alaskans, in both rural areas and in the cities, value a lifestyle which places importance on subsistence fishing and hunting. The strength of the land, rivers, and coastal waters which provide sustenance, is often seen as the source of our independence and self-reliance.

Many Alaskans like to be in control of the forces which influence their lives. Being at the mercy of the international economy is not a pleasant thought for many Alaskans.

Sustainable Economies and Lifestyles

The current emphasis of the Alaskan economy on the exporting of natural resources and the importing of manufactured products can not last forever. Many of our natural resources, such as oil, are not renewable. They will eventually run out.

Before this happens, we need to develop a *sustainable* economy to support our chosen lifestyles. Appropriate technology could provide some help in

doing so. A major goal of this course is to examine possible ways of using appropriate technologies in Alaska, to work towards a secure and fulfilling future.

Alaska: Member of a Small Planet

Modern technologies have helped to make the Earth a small planet. It is no longer possible to easily isolate ourselves from events of the world. It is increasingly difficult to live in such a way that we do not influence other members of our planet.

This is as true for Alaskans as for other citizens of the planet. Therefore, a major emphasis of this course is to understand the world in which we live. In this way we will be better able to understand the needs of our own communities.

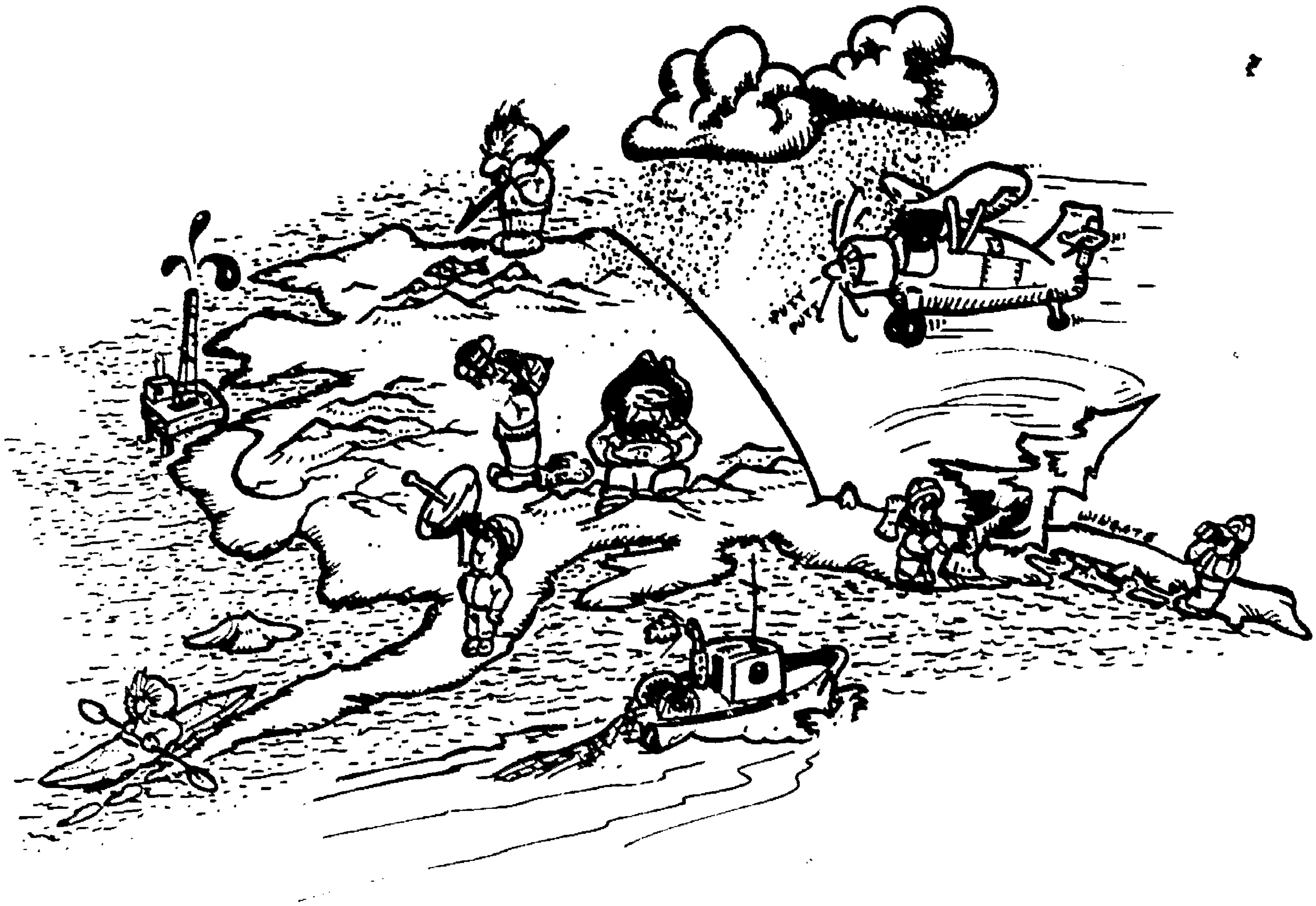
The influence we have on other people's lives means added responsibilities. The vast riches of Alaskan natural resources can be a powerful source of influence in our world. We need to ask ourselves how this power should be used in a world growing short of resources.

Questions such as this have no simple answers, but are important to ask. In this course we will be asking many difficult questions. We are hoping that you will join us in searching for a few answers.

THERE IS NO WORKSHEET FOR YOU TO COMPLETE.

APPROPRIATE TECHNOLOGY

LESSON 3



APPROPRIATE TECHNOLOGY

LESSON 3

SOME QUESTIONS

INTRODUCTION

The purpose of this lesson is to help you better understand what you read in the first two lessons.

You will be defining a few terms, making a few calculations, and answering some questions.

You might find the use of a dictionary helpful in completing this lesson. You might also want to discuss some of the information and ideas presented in the first two lessons with your teacher, other students, and members of your family. Probably your parents remember many of the historical events mentioned in these lessons.

COMPLETE THE FOLLOWING WORKSHEET.

APPROPRIATE TECHNOLOGY

WORKSHEET

LESSON 3

1) Use some or all of the following words and phrases to define the word ***economy***. Try to define it yourself. Then look at the answer given below.

industries	relationships between
people	selling and buying
products	natural resources
system	

Here is one possible answer:

An economy is a system of relationships between natural resources, people, and industries. The production of, selling of, and buying of resources and products are important parts of an economy.

2) What does ***gross national product*** mean?

3) What is meant, in Lesson #2, by ***average yearly income per person***?

4) Calculate the average yearly income per person for the entire world. Try to answer this yourself, using the information presented in the table on the first page of Lesson #2. Then look at the an-wer below.

ANSWER:

Using the table on the first page of Lesson #2, we can make the necessary calculations. First we determine the total yearly income of the world. Then we divide this by the total number of people in the world.

INCOME OF
VERY LOW-INCOME = 2.3 billion people X $230 per person =
COUNTRIES

$529 BILLION DOLLARS

(continued on next page)

INCOME OF
LOW-INCOME = 1 billion people X $1420 per person =
COUNTRIES

$1420 BILLION DOLLARS

INCOME OF
HIGH-INCOME = 1 billion people X $7960 per person =
COUNTRIES

$7960 BILLION DOLLARS

TOTAL INCOME OF THE WORLD = (529 + 1420 + 7960) billion dollars =

$9909 BILLION DOLLARS

TOTAL POPULATION OF THE WORLD = (2.3 + 1 + 1) billion people =

4.3 BILLION PEOPLE

AVERAGE YEARLY INCOME PER PERSON FOR THE WORLD	=	$9909 billion dollars divided by 4.3 billion people	=	**$2304**

If we divide this by 365 days, we get the average *daily* income for each person in the world: $6.31! This income must cover all expenses, including the building of highways and the manufacturing of military weapons. It is *not* the amount available for each person to spend. Also, we need to remember that wealth in the world is not shared equally. If you want, calculate the daily average income for a person in the very low-income countries (more than 1\2 of the population of the world). [answer: $230/365 = 63 cents]

5) Define the following words. In addition to Lesson #2, you might want to use a dictionary.

embargo:

recession:

6) In your own words, describe the crisis facing the rich countries, as presented in Lesson #2. Take your time, and do this carefully. You might want to first reread parts of Lesson #2, and make an outline. The following quotation might also help.

> *For many years after World War II, it was really the United States that provided both the impulse* [motivation] *to create the structure of international relations and the sanctions* [approval or punishment] *needed to sustain it. But US influence on the rest of the world has been declining for many years.*
>
> *The decline is most definable in the statistical world of economics: At the close of the war, our GNP was half of the world total; today it has fallen to about 22 percent and continues to fall. Strategically, the US no longer overshadows the USSR as it once did. Also, the political, economic, and even the military price of using our awesome military arsenal against another nation has risen steeply in recent decades. Most important of all, our moral authority or power to inspire emulation* [imitation] *and cooperation abroad has deteriorated more rapidly than our real power. Some of this decline was inevitable, as the nations of Western Europe regained some of their old stature, as the third world acquired new importance, and as the US tarnished its national and international image.*

John Hamilton
US State Department desk officer for Tunisia
quoted from an editorial in *The Christian Science Monitor*, page 22, February 1, 1983

(*There is more room for your answer on the next two pages.*)

7) Define the following words and phrases. In addition to Lesson #2, you might want to use a dictionary.

social movement:

innovative:

sustainable:

renewable resources:

8) Describe three or more important features of appropriate technology.

9) Do you think that appropriate technology can help solve the crisis facing the rich countries? What is *your* opinion? Give reasons for your answer. [If you disagree with some of what is presented in Lesson #1 and Lesson #2, don't be afraid to say so!]

10) If you had complete control of Alaska's natural resources and industries, what would you do?! Describe what life in Alaska might be like in the year 2000, if *you* could direct the future of the state!

11) What do you think life in Alaska will actually be like in the year 2000?

12) Do you think that appropriate technology has anything to offer to Alaskans? Why or why not?

CHAPTER 2

A HISTORY OF HUMAN TECHNOLOGIES

We shape our tools; thereafter, our tools shape us.

Marshall McLuhan

Matter, energy, vast reaches of space, and time--these hardly seem the ingredients for a planet teeming with life. On the firey anvil of the Solar System, our planet was born about 4.7 billion years ago.

While continents were being formed and demolished, life took hold during the youth of the earth. The oldest known fossils are 3.4 billion years old.

Though life started early, many eons passed before large, complex plants and animals evolved. About 400 million years ago fish with primitive lungs crawled onto land and transformed into the first amphibians. At this time, until about 265 million years ago, luxuriant swamps covered much of what is now North America, Russia, and China. The dying plants and animals of these swamps developed into extensive beds of coal. The formation of oil and natural gas deposits, mostly from dying plants in coastal waters, had also begun.

The acccumulated adaptations of the amphibians to conditions of life on land eventually gave rise to the dinosaurs, who ruled the planet from 200 million years ago until comparatively recent times--65 million years ago.

During the reign of the dinosaurs the beginnings of new lifeforms arose. By the time the dinosaurs mysteriously disappeared, flowering plants and mammals had become widespread.

50 million years ago the ancestors of monkeys, gorillas, and humans were swinging in the trees. The major adaptive trends that would make the development of human culture possible had been established: agile hands and wrists, good eyesight, advanced hand-eye coordination,

and the passing of information from one generation to the next by learning. Behavior was becoming *learned*, not just biologically inherited. Social evolution was joining biological evolution as a powerful force.

During the most recent 3 million years the tool-using species has arrived—humans. By 400,000 years ago our ancestors were using fire. By 10,000 years ago they were giving up the nomadic life of hunting and gathering to begin planting crops, develop cities, and to continue a revolution of technological development which is still going on.

In this chapter you will learn about that technological revolution. You will also learn how people started to use coal and oil as sources of energy, resulting in technologies which have had far-reaching affects on our lives today.

History is a window into the past and the doorstep to the future. It is not merely a collection of facts and dates to be memorized. The intent of this chapter is *not* to bore you with meaningless details, but to open horizons. It is meant to help you understand human technologies—to better understand yourself and your world. More importantly, it is to give you insight and power for shaping your own future.

If a man dwells on the past, he robs the present,
But if a man ignores the past
He may rob the future.
The seeds of our destiny are nourished
By the experiences of our past.

Chinese proverb

A HISTORY OF TECHNOLOGY

LESSON 1

written by Jacob Bronowski, and was the basis of a television series. The title is *The Ascent of Man*. In this book there is a picture of an outline of a hand which appears very similar to the handprints we made on the ceilings of the buildings we lived in. It was probably made in a similar way.

But what does it mean?

The handprint in Bronowski's book was made *several thousand years ago*, in a cave located in Spain. According to Bronowski, it says: "This is man!"

The handprints are products of the human brain directing the hand. Some people would call this art. I prefer to call it technology, which to me includes art. Whatever it is called, the process, the brain directing the hand to produce something, is the same.

Human Imagination

Bronowski presents an important distinction of the human race.

> Art and science are both uniquely human actions, outside the range of anything an animal can do. And here we see that they derive from the same human faculty: the ability to visualize the future, to foresee what may happen and plan to anticipate it, and to represent ourselves in images that we project and move about inside our head, or in a square of light on the dark wall of a cave or television screen. (*The Ascent of Man*, page 56)

What Bronowski is talking about is *imagination*, which he says is unique to humans. He compares the functioning of

this imagination to a telescope, a way of looking into the past and the future as only humans can. Bronowski calls this a gift:

> There are many gifts that are unique to man; but at the centre of them all, the root from which all knowledge grows, lies the ability to draw conclusions from what we see to what we do not see, to move our minds through space and time, and recognise ourselves in the past on the steps of the present. (*The Ascent of Man*, page 56)

We are about to put this "gift" to work for us and take a rollercoaster ride through history. Along the way we will look at some key stages in the history of human technology. This technology, as you will see, is produced by the constant growing and widening of the human imagination.

HUNTERS AND GATHERERS

The people who made the cave drawings were hunters and gatherers. We know this because some tools and animal bones were also found in these caves. They were not the first hunters, nor were they the first type of humans.

Most ***anthropologists*** believe that the first humans were vegetarians. Anthropologists are scientists who study human cultures.

The early humans probably originated in Africa, where they wandered about on the African plain searching for various kinds of plants to eat. People who wander all the time, rather than live in one set place, are called ***nomads***.

A Change of Diet

Some of our distant ancestors decided to try a change of diet. They continued to eat plants, but the major portion of their diet began to be meat. This has had some far-reaching consequences, because meat is a more concentrated source of protein than are plants.

The eating of meat reduced the amount of time these early hunters spent feeding themselves by two-thirds. In other words, if it took humans 30 hours a week to receive enough nutrition by eating plants, by eating meat they could receive about the same nutrition in 10 hours. This gave them more time for other activities.

Improved Hunting and Language: New Inventions

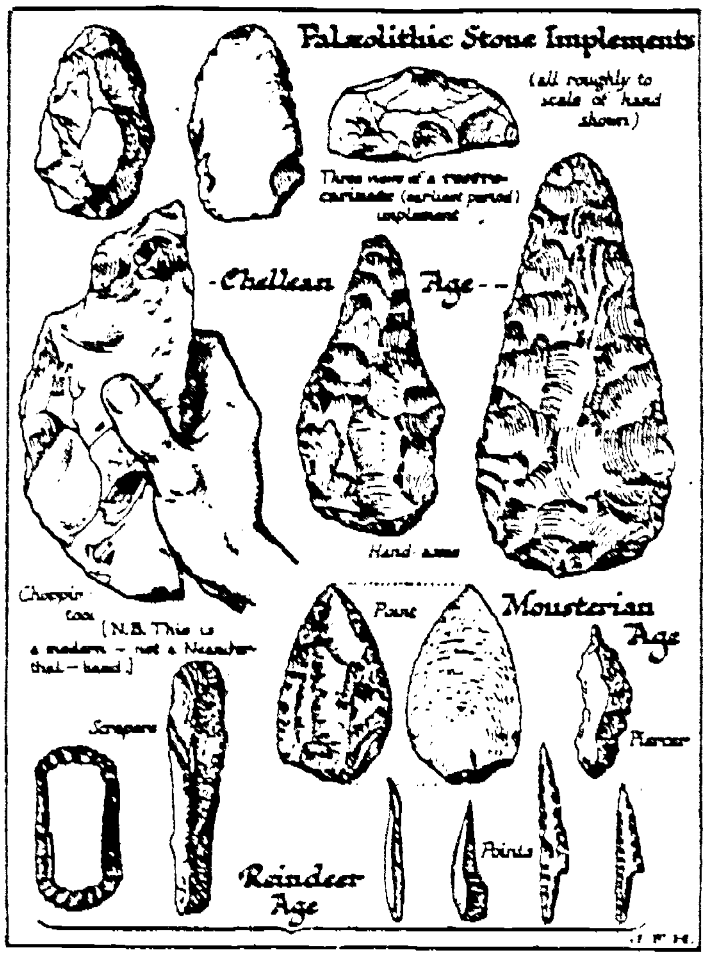
Among other things, the hunters used their free time to invent better weapons and methods of hunting. Over a long period of time they developed axes, spears, bows and arrows, traps, and snares. Hunters improved on these tools by making them sharper, sturdier, and easier to use.

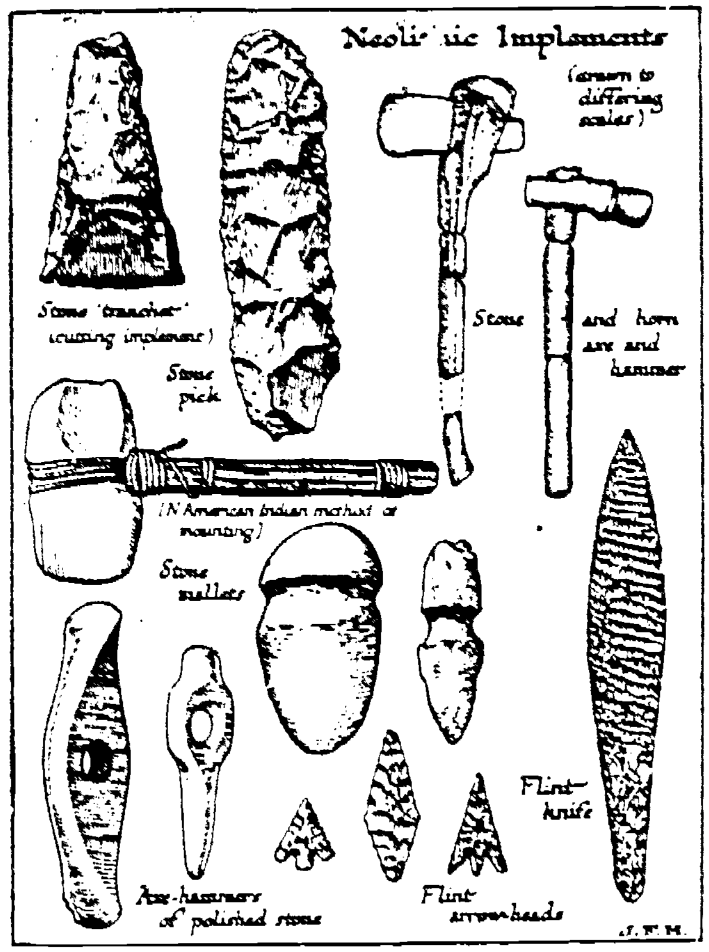
The discovery of fire allowed them to forge arrowheads, spearpoints, knives, and axes out of copper, then bronze, and much later, iron.

The hunters also had to learn to cooperate with each other to kill larger animals. To do this they had to plan, and in order to plan, they had to improve their communication with each other. Here was the birth of language. H. G. Wells relates the importance of language to humans.

> Until language had developed to some extent there could have been little thinking beyond the range of actual

experience, for language is the instrument of thought as bookeeping is the instrument of business. It records and fixes and enables thought to get on to more and more complex ideas. It is the hand of the mind to hold and keep. (*The Outline of History*, page 92)





The tools on the left represent some of the earliest made by humans. Those on the right are from a later stage in the development of human technology. How are they different? What had humans learned? How do these tools differ from those we use today?

Hunters Forced To Become Nomads

As humans became more efficient at hunting, they became capable of killing animals faster than the animals could reproduce. Some groups of hunters were forced to move over wider and wider areas in search of food.

> Hunting cannot support a growing population in one place: the limit for the savannah was not more than two people to the square mile. At that density, the total land surface of the earth could only support the present population of California, about twenty millions, and could not support the population of Great Britain. The choice for the hunters was brutal: starve or move. (*The Ascent of Man*, page 45)

The hunters moved over great distances. About a million years ago they were in North Africa. Seven hundred thousand years ago they were in Java. By four hundred thousand years ago, they moved east to China and west to Europe. About twenty thousand years ago, the cave drawings we mentioned earlier were made in Spain.

About 15,000 years ago Siberian hunters crossed the Bering Sea land bridge into Alaska. They might have been the first humans to arrive in North America. The crossing was made possible the lowering of the sea, as the earth's water was frozen into the glaciers of an ice age.

Culture: A Response To Environment

The nomadic hunters encountered wide-ranging differences in climates and environments. Isolated groups adapted to deserts, tundra, grasslands, forests, coastal regions, and other environments. These groups diversified into many human cultures, each with its own technologies for survival. Differing needs and available resources led to a fascinating assortment of cultures, from the Bushmen of Africa, to the Eskimos of Alaska.

Given the differences, there is much that is similar with all nomads. They all have tools and shelter that can be packed up and taken with them as they

wander. Also, nomads tend to live in family groups or groups with a small number of individuals.

Modern-Day Nomads

Some of the oldest existing cultures are nomadic. The Australian Aborigines have been around for forty thousand years. The African Bushmen of today, some say, are the original inhabitants of Africa. Eskimos were early settlers of Alaska. These ancient cultures have changed very little for thousands of years. Anthropologists digging in prehistoric sites often find the same kinds of tools as are currently used by members of these cultures. In some cases these people had been exposed to modern technological innovations, but choose to use their own tools.

Other nomads have kept pace with the changing world. The Gypsys are an interesting example. Their name was given them by the ancient Greeks, who thought that they came from Egypt. Social scientists who have studied the language of the Gypsys think that they actually came from northern India. Wherever they originated, they exist now in most parts of the world. H. G. Wells noted in 1920 that they were found in all European countries, working as repairmen, peddlers, showmen, horsetraders, fortune tellers, and beggars.

> I remember, as a boy in Boston, Gypsies moving into empty stores in the summertime and telling fortunes. A few years ago, while I was sitting in a restaurant in Greece, some Gypsies came in selling rugs. Last year, a woman I know in Juneau had the dents in her car repaired by Gypsies. They seem to wander all over the world doing whatever they can to stay alive, as

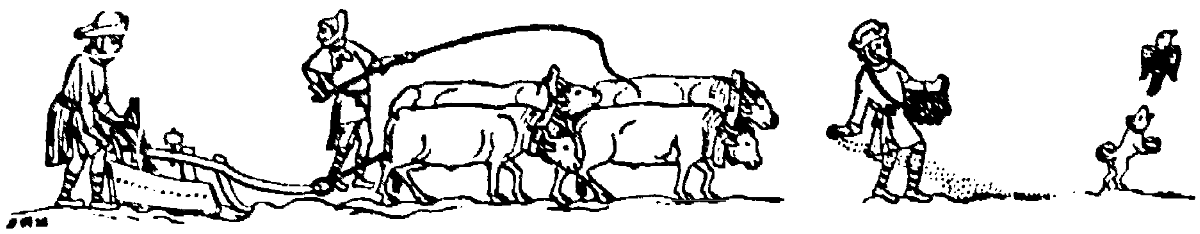
> they have, for who knows, maybe thousands of years.
>
> --Paul Helmar

Our early ancestors were nomadic, and perhaps we still have much of their blood in our veins. As Wells puts it:

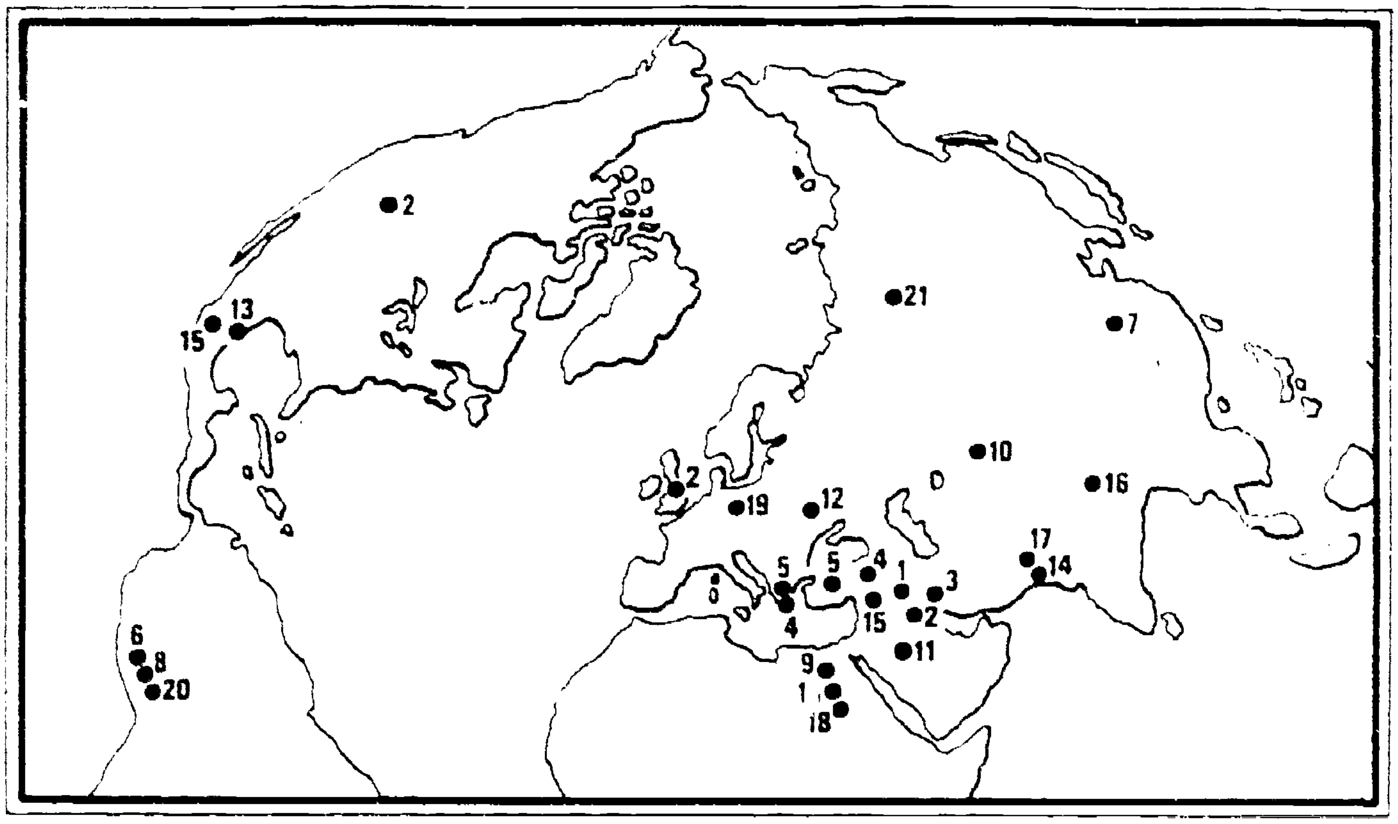
> Civilization is so new a thing in history, and has been for the most part so very local a thing, that it has still to conquer and assimilate most of our instincts to its needs. In most of us, irked by its conventions and its complexities, there stirs the nomad strain. We are but half-hearted home keepers. (*The Outline of History*, page 698)

THE FOOD PRODUCERS

Humankind hunted and gathered food for several hundred thousand years before developing other methods of survival. Then people began to domesticate animals and to cultivate



crops--to *produce* food, not just *collect* it. About 10,000 years ago humanity settled down. Direct control of animals and plants allowed the wandering tribes to build permanent settlements. Soon, the human population began to greatly expand.



1	**SHEEP** Zawi Chemi Shanidar Iraq (9000 B C)
2	**DOG** Jarmo Iraq (9000 B C) Jaguar Cave Idaho (8400 B C) Star Carr England (7500 B C)
3	**GOAT** Ali Kosh Iran (8000 B C)
4	**PIG** Cayonu Turkey Greece (7000 B C)
5	**CATTLE** Thessaly Greece Anatolia Turkey (7000 B C)
6	**GUINEA PIG** Ayacucho Basin Peru (6000 B C)
7	**SILK MOTH** Hsi yin t sun China (3500 B C)
8	**LLAMA** Andean Highlands Peru (3500 B C)
9	**ASS** Nile Valley Egypt (3000 B C)
10	**BACTRIAN CAMEL** Southern U S S R (3000 B C)
11	**DROMEDARY** Saudi Arabia (3000 B C)

12	**HORSE** [Ukraine] U S S R (4350 B C)
13	**HONEY BEE** Nile Valley Egypt (3000 B) Mexico (? B C)
14	**WATER BUFFALO** Indus Valley Pakistan (2500 B C)
15	**DUCK** Near East (2500 B C) Mexico (? B C)
16	**YAK** Tibet (2500 B C)
17	**DOMESTIC FOWL** Indus Valley Pakistan (2000 B C)
18	**CAT** Nile Valley Egypt (1600 B C)
19	**GOOSE** Germany (1500 B C)
20	**ALPACA** Andean Highlands Peru (1500 B C)
21	**REINDEER** Pazyryk Valley Siberia U S S R (1000 B C)

GEOGRAPHICAL ORIGINS OF DOMESTICATED ANIMALS

Domestication of Animals

The first step in the food production revolution was the domestication of animals. Animals were herded and some even trained to carry loads or to do other work. Bronowski outlines how this took place:

> The sequence of domestication is orderly. First comes the dog, perhaps even before 10,000 B.C. Then come food animals, beginning with goats and sheep. And, then come draught animals [animals that carry loads or do other work] such as the onager, a kind of wild ass. (*The Ascent of Man*, page 79)

Bronowski thinks that there might have been an intermediate step between the stages of hunting and herding of animals. The Lapps, who live in the extreme north of Scandanavia, are a modern example of this intermediate cultural step. The reindeer, which the Lapps depend on as their primary food source, are still wild animals. They have not been domesticated. The Lapps simply move where the reindeer move.

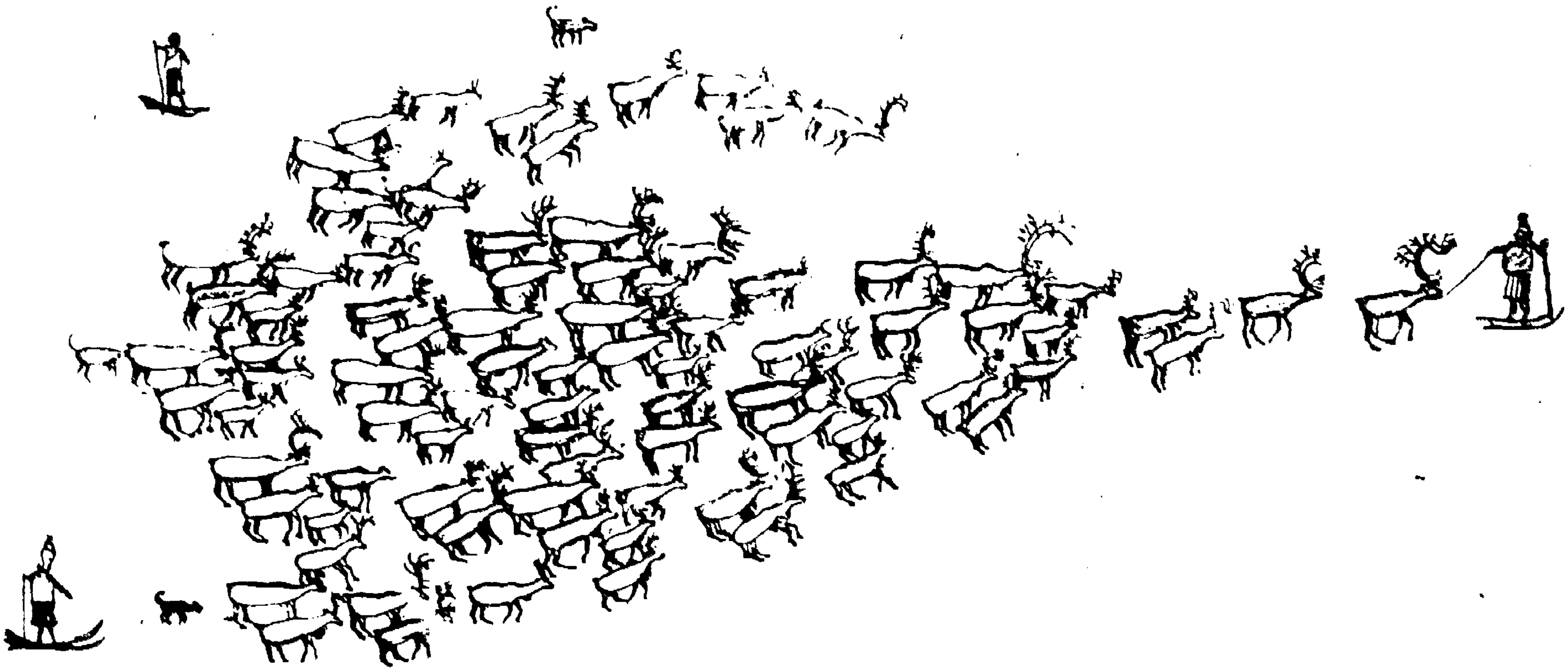
> Even though the reindeer herds are in effect still wild, the Lapps have some of the traditional inventions for controlling single animals that other cultures also discovered: for example, they make some males more manageable as draught animals by castrating them. It is a strange relationship. The Lapps are entirely dependent on the reindeer--they eat the meat, a pound a head each [per person] every day, they use the sinews and fur and hide and bones, they drink the milk, they even use the antlers. (*The Ascent of Man*, page 48)

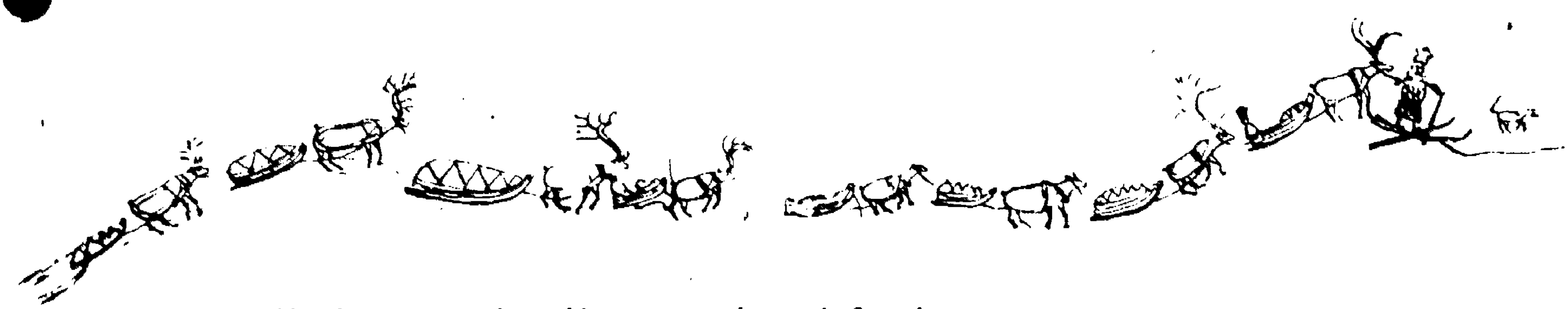
During the 1890's, Lapps were brought to Alaska to teach Eskimo people how to herd reindeer. We will talk more about this in a future lesson.

A Mobile Reservoir of Food

Tended herds of animals, domesticated or not, provide a "mobile reservoir of food," a large quantity of food stored for the future.

The transhumance life on the move in a landscape of ice
Drawn by the Lapp, Johan Turi, for his own written account of his people's life: pack animals move beside the wild herds. The lead reindeer buck is guided by a herdsman on skis





Hunters and gatherers stored food, such as nuts, grain, and dried fish and meat. But they couldn't store great quantities of this food to sustain their lives for very long. One reason for this is that their food was not found in one place.

Planting Crops and Living in Villages

The next major departure from the hunting and gathering lifestyles of the nomads was the planting of crops. This led to one of the most dramatic

changes in human culture, the settling of villages. Humans were increasingly taking control of their environment.

What made this possible? According to Bronowski, it was a combination of human and natural events.

We have already mentioned that humans, from the earliest of times, were eating plants. In most situations it was necessary to continue eating plants, because meat is not a good source for some nutrients, such as vitamin C.

It is not difficult to imagine an early nomad planting and tending a crop. Early people had shown considerable inventiveness in improving tools used for hunting. But to speed up the birth of agriculture, a "strange and secret act of nature" appeared. The world climate began to change. The temperature rose and the ice that covered much of the world began to melt. With this climatic change came a new burst of vegetation.

A New Variety of Wheat

In the Middle East a new variety of wheat appeared, called "Emmer." It was an early form of the wheat now used to make bread. This bread wheat was plumper than earlier forms, and had an unusual characteristic--the seeds were so tightly clumped together that the wind could not blow the seeds off the plant.

This quality made the wheat easier to harvest. It also made the wheat dependent on farmers, because it could not easily disperse its seeds in the wind to reproduce itself. Plant and humans had formed an alliance which benefited both.

Agriculture started about 10,000 years ago in the Middle East. There

were similar occurences in other parts of the world. Evidence indicates that prehistoric agriculture in North and South America began with a relationship between farmers and corn which was similar to the one found in the Middle East between farmers and wheat.

Agriculture Gives Rise to New Technologies......

Following the establishment of agriculture there was a burst of inventions: the plow, harnesses for oxen, the wheel, sails for boats, and bricks, to name a few. The new farmers

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also began building permanent houses, often grouped together in villages.

........and Methods for Measuring Time and Land

With agriculture came the need to understand the seasons. Farmers had to learn how to predict the passing of days more accurately and over a longer period of time. They needed to know when to sow and when to harvest their crops.

One of the earliest ways of reckoning time was by observing the changing phases of the moon. From full moon to full moon is one month. This might be how time was measured in the book of Genesis in the Bible:

> ....if one reads the great ages of the patriarchs who lived before the flood as lunar months instead of years, Methuselah and others are reduced to a credible length of life. But with agriculture began the difficult task of squaring the lunar month with the solar year; a task which has left its scars on our calendar to-day. Easter shifts uneasily from year to year, to the great discomfort of holiday-makers; it is now inconveniently early and now late in the season because of this ancient reference of time to the moon. (*The Outline of History*, pages 98 & 99)

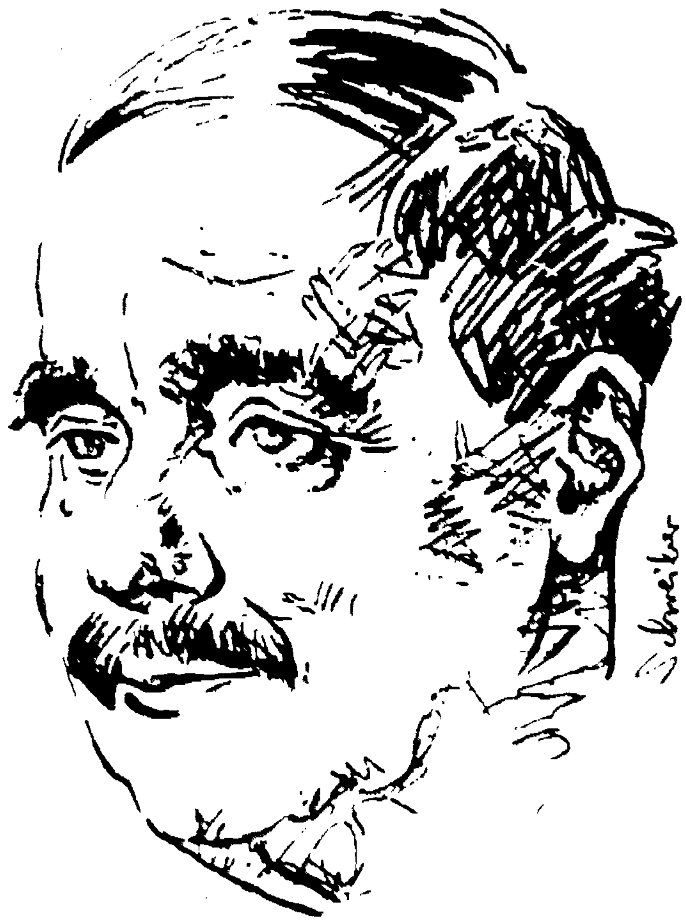
The angle of the sun on the horizon is a method used to measure the length of a year. The lunar month and solar year are still the way we perceive the passage of time.

As you will learn in a later lesson, the history of timekeeping and the history of technology seem to run along parallel lines.

The need to measure agricultural

land spurred, on the development of geometry (geo = earth; metry = to measure). The skills of measuring land contributed to the development of mathematics. And mathematics greatly facilitated the development of science and technology.

In the next lesson we will discuss the emergence of cities and the birth of science.



H. G. WELLS

COMPLETE THE FOLLOWING WORKSHEET.

LESSON 1

A HISTORY OF APPROPRIATE TECHNOLOGY

WORKSHEET

1) In the introduction to this chapter you were presented with the central core of an evolutionary philosophy. *

The first lesson of this chapter leads you on an excursion through the early stages of human culture. *Imagination* is presented as being a unique gift which sets humans apart from other animals.

How do you think that imagination and the following adaptive traits have led to the development of human civilization?

1) agile hands and wrists
2) good eyesight
3) advanced hand-eye coordination
4) the passing of information from one generation to the next

Use *your* imagination to answer this question!

* Theories of evolution are frequently hotly contested. Often it is claimed that the *philosophy of materialism* is the foundation of these theories, leaving no room for religious beliefs. We, the authors of this course, do *not* see evolution theories and spiritual beliefs necessarily in conflict with each other. Personally, we feel, as E. F. Schumacher did, that a world-view based on *materialism* is a dreadful blight of modern times. But we believe that the understanding of material ev ution is *one small part* of a greater awareness that can lead to spiritual attainments. What we would like to see is the abolishment of simplistic "either-or" arguments which are often at the center of the confrontations which divide the human race.

2) If a human generation is considered to be 50 years in length, how many generations have passed since humans first settled down to an agricultural way of life (10,000 years ago)? How many generations since fire was first used by humans (400,000 years ago)? How many generations since early primates, our ancestors, were swinging in trees 50,000,000 years ago?

answers: 200 generations since agriculture began
8000 generations since humans first used fire
1,000,000 generations since early primates...

3) Describe how ancient vegetarians became hunters and gatherers, and then settled down to an agricultural way of life. You might want to make an outline before attempting to answer this question. Use all of the following words and phrases in your description.

new inventions	Emmer
agriculture	nomad
meat	vegetarian
fire	metals
cooperation	improved hunting tools
language	hunting and gathering
change in climate	improved agricultural tools
crops	

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4) It is often theorized that language and cooperation developed as a consequence of hunters needing to communicate with each other and to work together.

Pretend that you have a time-machine and have travelled back to the time of the hunters. Describe the hunters as they try to invent language and prepare for the hunting of the dangerous mastodon! (You might try communicating with a friend without using words!)

5) Language is a powerful technology. "Definitions" are tools of language. A definition is an *approximation* of meaning, used to simplify our thinking process. Rarely is a definition extremely accurate!

Design your *own* definition of the word *technology*. Then decide, according to *your* definition, whether or not a spider web is a technology. Also, decide whether or not a nylon fishing net is a technology. If you decide one of these is a technolgy and the other is not, explain why.

6) Large-scale agriculture is a newcomer in Alaska. Most of our food is now imported, but the hunting and gathering tradition lives on! *Subsistence* and *sport* hunting and fishing, and the gathering of berries, are highly valued activities of our culture. Commercial fishing, an important industry in Alaska, remains as the most extensive form of hunting in the world.

What are the sources of the food which sustains *your* life? Hunting and gathering? Agriculture? Explain.

7) Methods of food storage were important technologies in the development of human cultures. What methods of food storage do *you* use?

8) The technology of agriculture led to the birth of techniques for measuring time and land. How do you think the development of these skills influenced the further development of human culture?

9) Look at the cover of this course. Does it "tell" you anything? Does it have any meaning for you? What is *your* interpretation of the cover?

10) **OPTIONAL QUESTION:** The hunting and gathering nomads populated the world. New environments and long isolation of various groups of people led to the evolution of many races.

What is the history of your own family? Where did your ancestors come from? How far back can you trace your family? Do you sometimes feel the wandering nomad spirit in your blood?!

11) **OPTIONAL QUESTION:** *Billions of years* passed slowly by while life transformed into animals which could move about on land. *Hundreds of millions of years* led to the arrival of intelligent primates and eventually to early humans. A *few million years* culminated in human cultures which used fire and hunted for meat. A *few hundred thousand years* were enough for the growing inventiveness of the tool-using humans to learn how to domesticate animals, cultivate crops, settle villages, and develop language. In a mere *10,000 years*, a fleeting moment in the vastness of time, we enter the world of today.

Many a thinker has wondered if the people of today have adapted to the *speed* of change which we live with in the 20th century. Clearly our history shows an ever-increasing rate of change which our ancestors have adapted to. But has the rate of change passed our ability to keep up with it? What do *you* think? What is *your* opinion? (Use your own paper.)

A HISTORY OF TECHNOLOGY

LESSON 2

Machu Picchu, in the Andes Mountains of Peru

"The streets of a city that none of us has ever seen, in a culture that has vanished. Mortarless joints and cushioned faces of the granite blocks characterize Inca masonry." -Jacob Bronowski

A HISTORY OF TECHNOLOGY

LESSON 2

CITIES, EMPIRES, AND THE BIRTH OF SCIENCE

[In the ancient city of Alexandria] clearly were the seeds of the modern world. What prevented them from taking root and flourishing? Why instead did the West slumber through a thousand years of darkness until Columbus and Copernicus and their contemporaries rediscovered the work done in Alexandria? I cannot give you a simple answer. But I do know this: there is no record, in the entire history of the Library [at Alexandria], that any of its illustrious scientists and scholars ever seriously challenged the political, economic and religious assumptions of their society. The permanence of the stars was questioned; the justice of slavery was not. Science and learning in general were the preserve of a privileged few. The vast population of the city had not the vaguest notion of the great discoveries taking place within the Library.

Carl Sagan
Cosmos, page 335

INTRODUCTION

The development of agriculture provided the technological basis for a new way of life.

In this lesson we discuss the birth of cities and some of the accompanying changes in human society. New technologies played a major role in these changes.

"Science" had its beginnings in the early cities. In the ancient Greek city of Alexandria many fertile minds were

brought together. Though many of the records of Alexandria were destroyed by the Romans, the Moslem Arabs managed to save much of the accumulated knowledge, to which they added their own achievements.

While reading this lesson, you should take notes. You will be asked to make an outline from your notes, and to summarize the lesson. Not only will this help you understand the ideas presented here, but it is good practice. The organizing and processing of information is a useful skill.

THE EMERGENCE OF URBAN SOCIETY

Nomads roamed the world for several hundred thousand years. The development of agriculture and the settling of villages, about 10,000 years ago, set the stage for further changes in human society.

Increased control over food production eventually led to the establishment of cities. New technologies made this a possibility.

Timekeeping, Temples, and Gods

Agriculture had given timekeeping a greater meaning. The need to know when to plant and when to harvest was probably one of the reasons for the building of temples, as centers for timekeeping.

> There had come into the life of man with his herding and agriculture, sense of a difference between the parts of the year and of a difference between day and day. Men were beginning to work--and to need days to rest. The temple, by its

festivals, kept count. The temple in the ancient city was like the clock and calendar upon a writing desk. (*The Outline of History*, page 178)

Timekeeping was only one function of the temples. They were built to the glory of some being or natural phenomena which humans considered to be greater than themselves, or that symbolized some quality which they adored. These gods took many forms. There were sun gods, hippopotamus gods, hawk gods, and cow deities. There were monstrous male and female gods, and there were gods that were lumps of meteoric stone which had fallen miraculously out of the sky.

Set
Egyptian god of darkness.

Anubis
darkness god.

Typhon
wife of Anubis, also known as the Terrible One

The cheerful
Bes

Temples Served as Community Centers

Temples became the center of other activities as well. Commercial exchanges and histories of events were recorded, using early forms of writing. Writing, computation, and methods of measurement have their birth in temples.

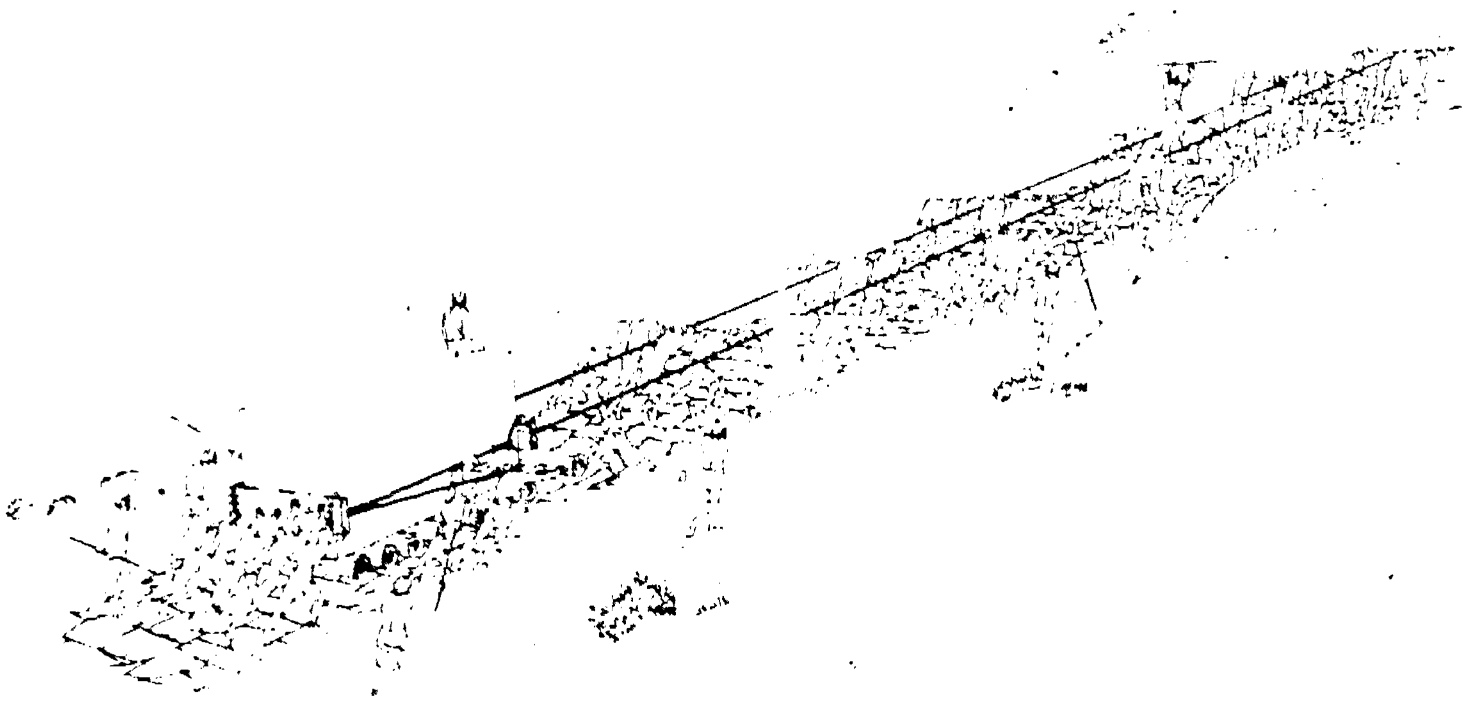
The early priests, or keepers of

the temple, were also doctors and magicians. People often went to them for medical help and guidance. The priests also led festivals and the celebration of other events. In this way the communities were held together. It was around the temples that cities were built. Life in many modern cities exhibits a similar structure.

While I was growing up in Boston, the city was divided into parishes of the Roman Catholic Church, each with its own church. When you asked someone where they were from, often they would give the name of their parish church. If someone had asked me where I lived, I would say Blessed Sacrament Parish. In this way the communities of Boston, a modern metropolis, were held together much like the ancient cities.

--Paul Helmar

Cities were not merely larger villages. The ways of life--the lifestyles--were quite different. Most villagers re food producers, while



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most of the urban dwellers were not directly engaged in the production of food. ("Urban" is an adjective which means "pertaining to or located in a city.")

The people in the cities were rulers, administrators, soldiers, priests, scribes, craftsmen, and slaves.

Slaves provided the basic source of energy for much of the labor in cities *for three thousand years.* They also did much of the work on farms and fought in wars. To a lesser degree, slavery has continued into the 20th century.

Urban Life Gives Rise to New Technologies

The needs of a large urban population living on a small area of land are quite different from the needs of villagers surrounded by the fields which they tend. Many technologies were invented to meet these needs.

A great quantity of fresh water was needed for drinking and bathing. Systems for the disposing of waste water became a necessity.

The new urban populace had to be fed. This was accomplished by the introduction of a more productive agriculture, based on extensive irrigation systems.

The needs for water were gradually met by the invention and construction of dams, levees, reservoirs, canals, and tunnels.

The early cities developed in the great river valleys: the Tigris and Euphrates Rivers of Mesopotamia (modern-day Iraq); in China along the Yellow River; in the Indus River Valley of Pakistan; and along the banks of the

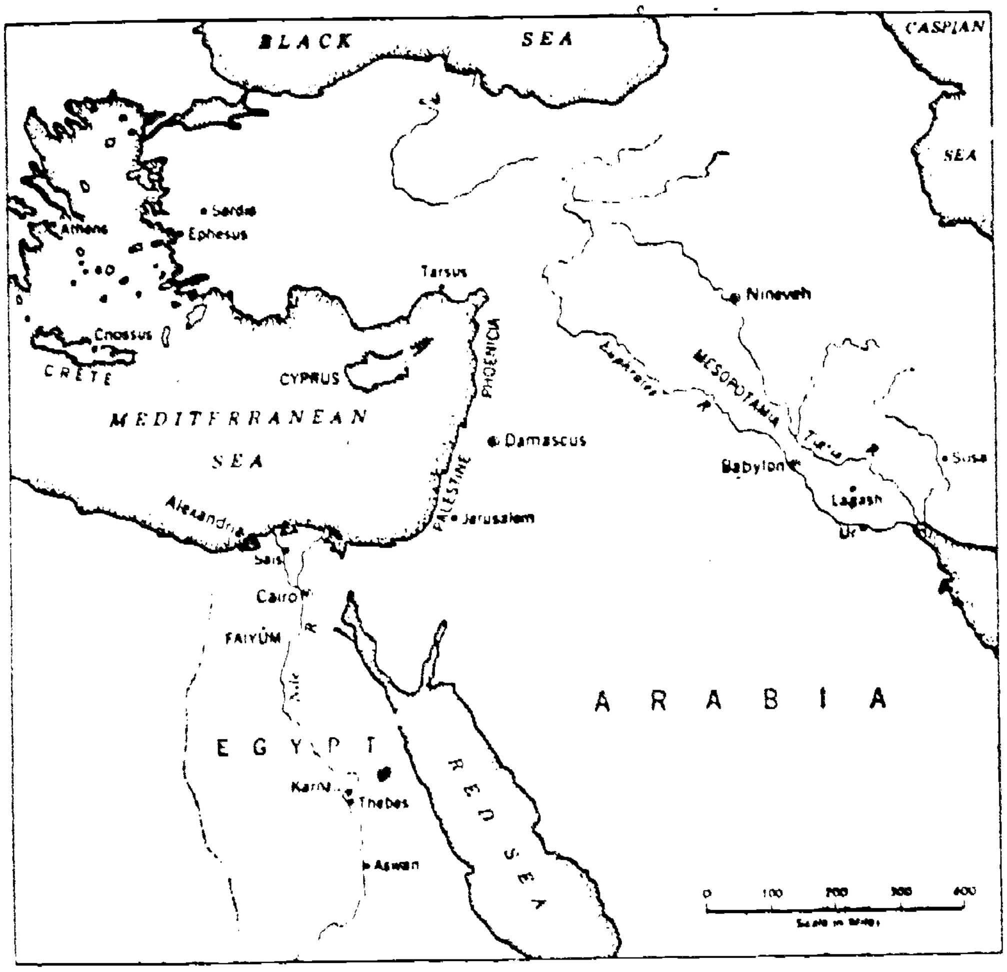
Nile River in Egypt.

The Sumerian and Egyptian societies were the foundation from which sprung modern Western Civilization. The Egyptians, although they established their cities somewhat later than the Sumerians, were more successful. Their culture became greater and more enduring. This was due, at least in part, to a quirk of nature.

In the eleventh century B.C. (about 3200 years ago), the Euphrates River changed its course. This proved to be more than the Sumerian irrigation systems could cope with and was partly responsible for the decline of their civilization. Another water-related problem might have contributed to the decline. Recent studies suggest that Sumerian agriculture suffered from salty and waterlogged soil, as a consequence of irrigation.

The Egyptians were much more fortunate. The Nile River flooded naturally with unfailing precision, fertilizing their fields and leaching

The Near East in ancient times



away salts. Apparently they did not have the waterlogging problem faced by the Sumerians.

Specialization, Trade, and Money

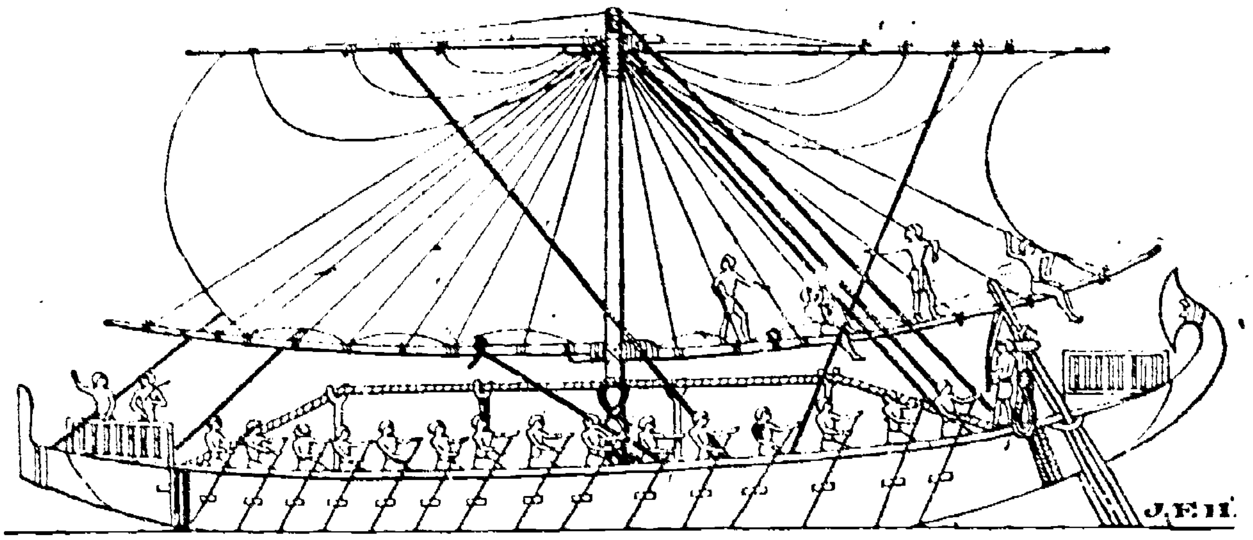
With the development of cities came an increase in the ***division of labor.*** Many types of work became highly specialized. People of various occupations became dependent on the work of other people--for food, raw materials, and for manufactured items.

Trade between people took on a new importance. To facilitate trade, systems of exhange were developed. Money became an important means to standardize the values of goods and services.

Transportation and Communication

As the people within cities came to rely more and more on each other and on imports for survival, transportation and communication became important necessities.

Natural resources had to be imported into the cities, and trade between cities was established. Extensive road systems, bridges, and ships were built.



Egyptian ship on the Red Sea, about 1250 B.C. [From Torr's "Ancient Ships."]
Mr. Langton Cole calls attention to the rope *truss* in this illustration, stiffening the beam of the ship. No other such use of the truss is known until the days of Modern engineering.

Consider the early Sumerian civilization. The Tigris-Euphrates Valley was lacking in many natural resources. There was clay available for making bricks, but there was no stone for building palaces, temples, and tombs. Stone blocks and timbers had to be hauled over long distances to the building sites. A transportaions system was a necessity.

Laws and Governments

Society was becoming very ***interdependent*** and the interactions between individuals and groups of individuals was becoming complex.

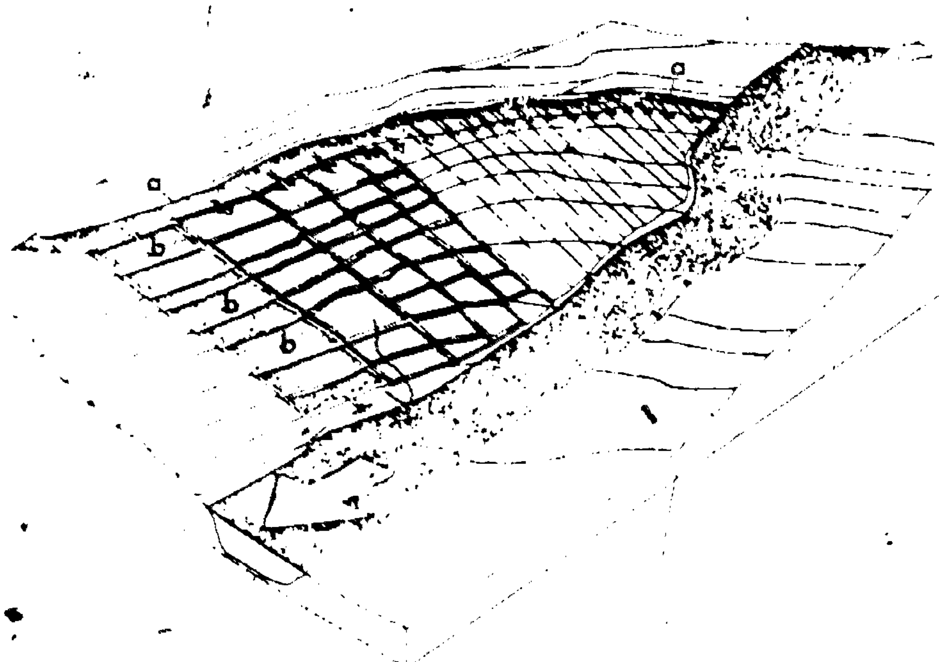
The urban way of life was becoming increasingly dependent on technologies. This is reflected in some of the first laws ever to be written.

In Mesopotamia, the land between the the Tigris and Euphrates Rivers, huge irrigation systems were built by the Sumerians. Maintaining these systems was of central importance to the society. According to Sigvard Strandh:

> After the powerful ruler Hammurabi had united the many small kingdoms along the Tigris and Euphrates in the 1780's B.C. [about 3765 years ago], he proclaimed a law which aimed at coordinating the operation of many networks of basins and canals which were then in use. Hammurbi's famous law was mainly a handbook for the organization and administration of the irrigation system. The law laid down the obligation of each citizen to contribute to the maintenance, operation and extension of the system. Also, there were detailed paragraphs about the punishment for any neglect of these obligations. The slightest disobedience or negligence in fulfilling the state's

severe requirements was seen as a cardinal crime. It was vital for the whole society that the irrigation system worked. (*A History of the Machine*, pages 169-170)

The ancient Egyptians irrigated areas normally untouched by the Nile's floods by digging feeder canals (a), which started far upstream of the area in question. The water was then allowed to trickle downwards, from basin to basin (b), when dams in the walls between them were opened. Thus, the soil in the basins was thoroughly soaked. Similar irrigation systems occurred in other early river cultures.



Survival in the early cities, as in the modern cities of today, depended on the close coordination of many people and their technologies. Laws and governments with vast powers took on the role of controlling this basis for survival. Unlike today, there was very little separation between the powers of religious leaders and other leaders of ancient society.

Urban Society

In summary, urban society had become a tightly interdependent way of life. The relationships between individuals, economic systems, religions, and governments had been

greatly affected by the development of technologies. And, many tecnologies had been developed as a consequence of the the emergence of urban society.

Many of the features of human culture that originated during these times are still with us today. Many people still live in cities, work at highly specialized jobs, use money as a means of exchange, are subject to the laws of strong governments, and are highly reliant on imported raw materials and food.

The Building of Empires

The power wielded by leaders of ancient cities was often absolute. Rulers were frequently worshipped as gods.

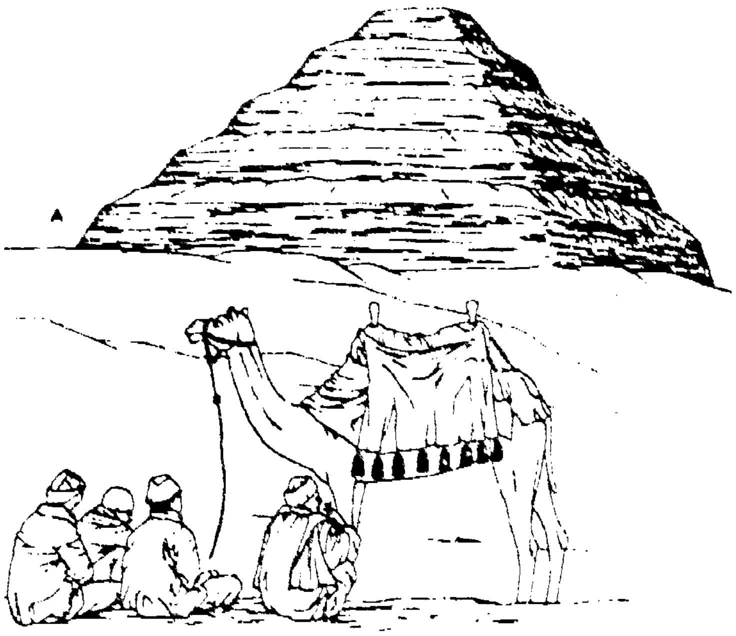
Empires were formed by bringing many cities under the control of one leader or government. Technological achievements were grandiose, reflecting the status of the rulers.

The Pharaohs of Egypt built mighty empires, graced with great cities, beautiful temples, tombs, and palaces. Some of these structures are the envy of modern engineers, not only for their size, but for the precision with which they were built.

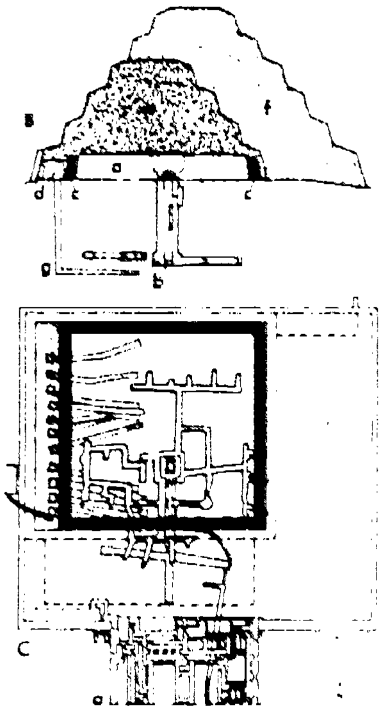
> It took decided skill in measuring distances and angles to transfer the plan of such a structure as a pyramid from the drawing to the site, and the engineer-architects of Egypt have left conclusive evidence that they possessed that skill. The average length of the sides of the Great Pyramid at Gizeh of Khufu, or Cheops, as the Greeks called him, was 755 feet 9 inches at the base. Two of the sides varied from that figure as little as 1 inch, and two of the angles were but 3 or 4

minutes in error. (*The History of Engineering*, pages 24-25)

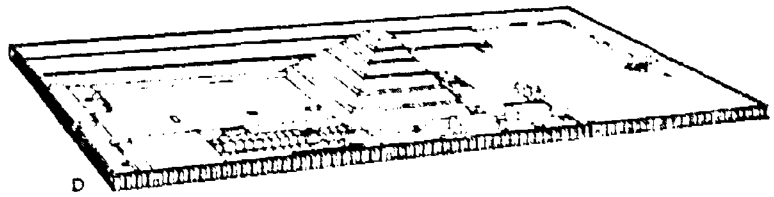
The Great Pyramid dates from 2700 B.C. (almost 4700 years ago) and is only one of the monumental building achievements of the Egyptians. To build this pyramid, the Egyptians used only the simplest mechanical principles and tools: wedges, mallets, chisels, straight levers, the inclined plane, and rollers made of hard acacia wood. So far as can be learned from the excavation of ruins, from inscriptions on monuments, and from written records, there was very little advance in building techniques during the four thousand years of Egyptian rule. The great achievements of Egyptian building is not seen in technique, but in three factors:



> One was the great supply of human labor...
>
> The second determining factor...was the concentration of these vast armies of workmen under the absolute control of a single man and his lieutenants. Neither time nor cost made any difference to a Pharaoh once he made up his mind to build a tomb for himself which would stand forever, or to shift the course of the Nile so that the desert might become fertile. Egyptian engineering was in the grand manner; its achievements were on a scale befitting one who called himself both god and king.
>
> The third factor...was the great quantity of building stone in the ledges of the Upper Nile Valley. (*The History of Engineering*)



A King Neter-khet's step pyramid, the first monumental structure to be built of stone.
B Longitudinal-section of the pyramid, which was originally built as a mastaba (a). The burial chamber (b) was situated at the foot of a 91-ft (29 m) shaft. However, Imhotep caused the dimensions of the structure to be increased, and the building was given an extra layer of stone all around (c). After that, the eastern wall was increased (d), and, later, the entire structure was incorporated into the pyramid (e). Later still, Imhotep caused further additions (f) to be made. (g) Tombs for members of the royal family.
C Underneath the pyramid is a maze of galleries and shafts. Certain galleries were intended for use as tombs for members of Neter-khet's family, whereas others were to connect the burial chambers with one another as the pyramid was built. Some of the shafts and galleries may, however, have been made only in order to lead grave robbers astray. (o) The funeral temple.



D Several temples and palaces were erected around the pyramid, and the whole area was surrounded by a high wall.

THE BIRTH OF SCIENCE

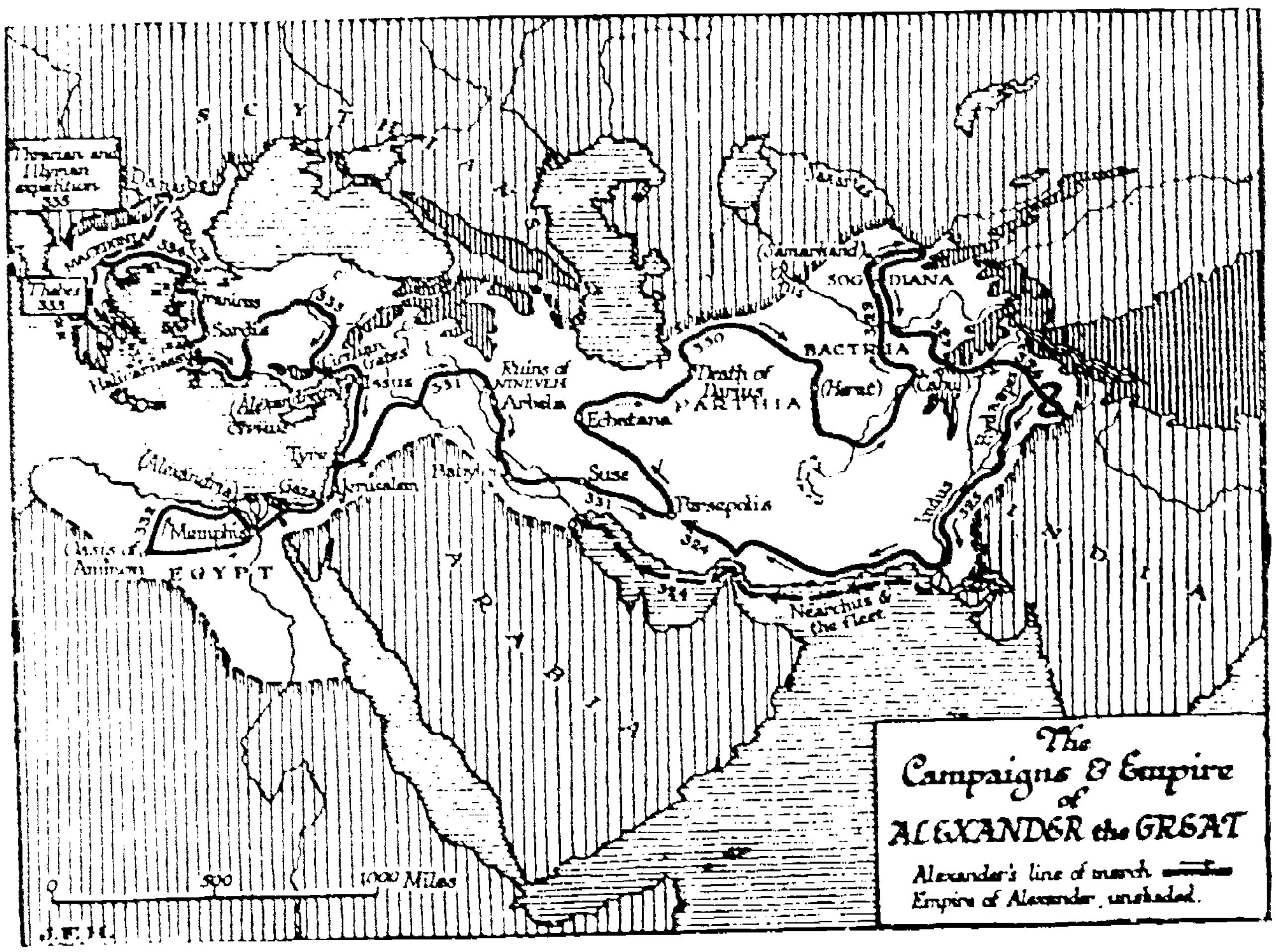
Alexander the Great
(silver coin of Lysimachus, 321-281 B.C.)

In 332 B.C. (a little more than 2300 years ago), Alexander the Great conquered Egypt. He also conquered much of the surrounding territory, creating an empire which extended from the Adriatic Sea in the east to the Indus River in the west. This is the region between the modern-day countries of Italy and Pakistan.

The "Cosmopolitan City" of Alexandria

Alexander established many new cities. The greatest city he founded was at the mouth of the Nile River in Egypt. He named it after himself, Alexandria, and installed Ptolemy as ruler.

Under the Ptolemaic dynasty, a fabulous university (called a museum) and library were built. Soon after, Alexandria became one of the greatest ***cosmopolitan*** cities.



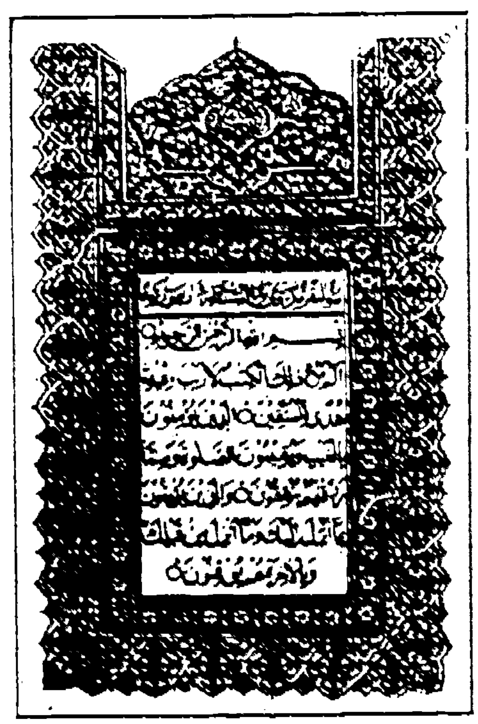
A cosmopolitan city is one which has cultural influences from many parts of the world. Cosmopolitan comes from the Greek word "kosmos," which means "universe" or "world." Alexandria aptly lived up to this term, because it had a population which represented many of the major civilizations of the world. The largest number of people were Greek, Jewish, Persian, and of course, Egyptian. Through the intermingling of varied cultural experiences, new ideas about mathematics, philosophy, religion, and the natural world were formed.

Language as a Key to the Broadening of Human Ideas

The Greeks brought to Alexandria a rich, expressive language which became widely known and used throughout the empire. Much of this language had been adapted from other civilizations.

> Ancient Greece....had taken over the Mediterranean alphabet and perfected it by the addition of vowels, so that reading and writing were now easy arts to learn and practice, and great numbers of people could master them and make a record for later ages. (*The Outline of History*, page 254).

It is from records written in the Greek language, and later through the Arabic language, that we are able to read about the discoveries and innovations made in Alexandria.



A Page of a Manuscript Copy of the Koran, the Bible of the Moslems

The Beginnings of "Science"

Aristotle (384-322 B.C.), Alexander's teacher, was the most influential philosopher of this period.

Aristotle set up his own school in Athens (called the Lyceum) on the Greek

mainland, with funds he received from Alexander. According to Wells:

> The peculiar relation of Aristotle to Alexander the Great enabled him to procure means for his work such as were not available again for scientific inquiry for long ages. He could command hundreds of talent [a form of money] for his expenses. At one time he had at his disposal a thousand men scattered throughout Asia and Greece collecting matter for his natural history. They were, of course, very untrained observers, collectors of stories rather than observers; but nothing of the kind had ever been attempted, had even been thought of, so far as we know, before his time. Political as well as natural science began. (*The Outline of History*, page 303)

This was the beginning of organized science, a systematic collection of observations for the purpose of trying to understand the world.

The funds for scientfic research were short-lived:

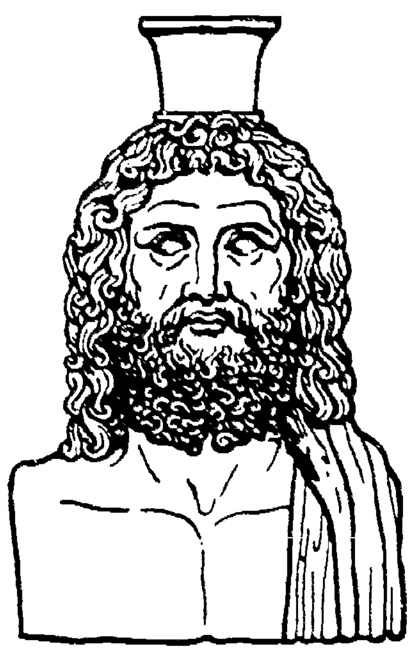
> The early death of Alexander and the breaking up of his empire almost before it had begun, put an end to the endowments [the financial aid] on this scale for 2,000 years. Only in Egypt at the Alexandrian Museum did any scientific research continue, and that only for a few generations. (*The Outline of History*, page 303)

For about one hundred years the Museum at Alexandria flourished. People came from many places to study and contribute their experience in many fields of knowledge.

Religion and Science

As its name implies, the Museum was originally founded to study religion. The "Muses" were nine Greek goddesses who presided over literature, the arts, and science. Centuries later, other great universities, such as Oxford and Cambridge in England, and Harvard in the United States, were established to study religion and to train Christian priests and ministers.

Today, many people consider science and religion to be quite separate pursuits. During the time of Alexander there was no such separation. Indeed, some scholars of the 20th century find no clear distinction between science and religion.



Serapis

"In this worship of Serapis, which spread very widely throughout the civilized world in the third and second centuries B.C., we see the most remarkable anticipations of usages and forms of expression that were destined to dominate the European world throughout the Christian era. The essential idea, the living spirit, of Christianity was, as we shall presently show, a new thing in the history of the mind and will of man; but the garments of ritual and symbol and formula that Christianity has worn, and still in many countries wears to this day, were certainly woven in the cults and temples of Jupiter, Serapis, and Isis that spread now from Alexandria throughout the civilized world in the age of theocrasia (the fusing of one god with another) in the second and first centuries before Christ." (p. 353, The Outline of History).

Some Great Alexandrian Scientists

The main thrust of the research at the Museum was directed at science and "the language of science"--mathematics. Many of the people who studied there were pioneers in these fields. To list

all of their names and achievements is beyond the scope of this lesson. We can only mention a few and highlight their efforts.

Best known among the mathematicians was Euclid. His book, *Elements of Geometry*, has undergone almost as many printings as the Bible, and has been read for 2,000 years by students from all over the world. (You have probably studied much of his work, if you have studied geometry.)

Eratosthenes measured the size of the earth and came within fifty miles of the true diameter.

Archimedes was the first to describe and show how simple tools work. These tools, called the "mighty five"--lever, inclined plane, wedge, screw, and the wheel--are still the basic mechanical tools used today.

Archimedes also formulated many mathematical theories. One of these, known as "Archimedes' Principle," describes the weight of an object immersed in a liquid. It states that the apparent loss of weight of a floating object is equal to the weight of the liquid that it replaces.

Archimedes standing on the Earth (which is flat) surrounded by water, air, fire, and the celestial spheres

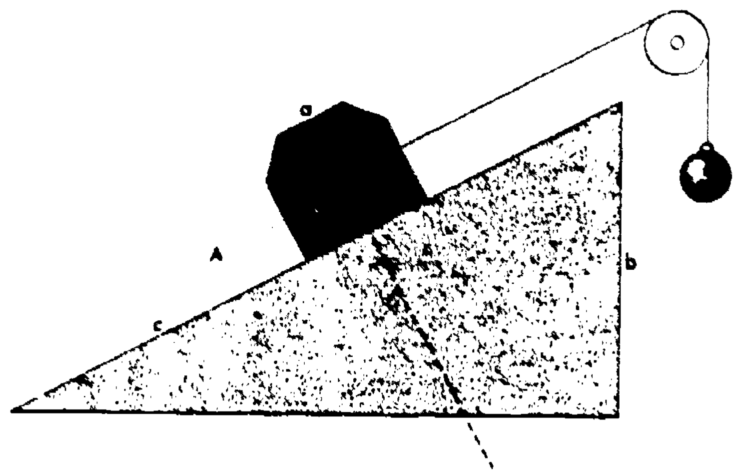
"Speculative Philosopers," Not Practical Inventors

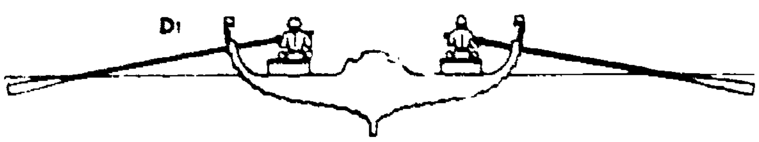
Most Alexandrian mathematicians and scientists were ***speculative philosophers***. They were more interested in speculating, which is to think about ideas, than in the practical applications of their discoveries.

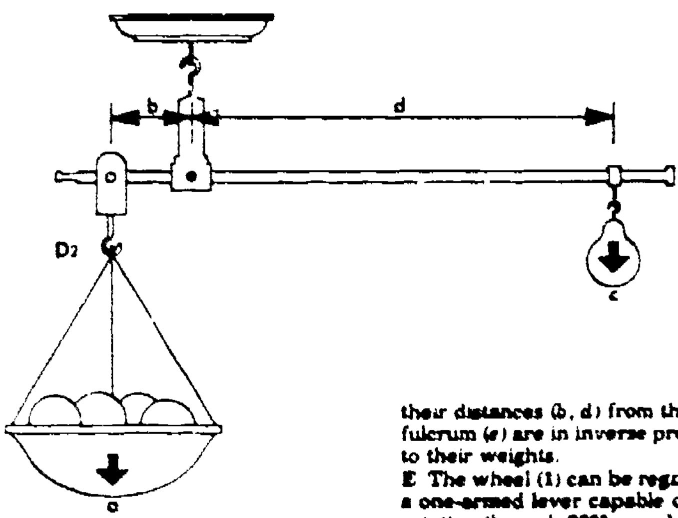
One notable exception was Archimedes, who built ingenious machinery for defending his native city, Syracuse, against the Romans.

Archimedes' "mighty five" tools, and how they work.

D The characteristics of a lever are that it pivots round a fulcrum and that it moves under the influence of an applied force, or effort, and a load. Two applications of the two-armed lever are shown here: the oar (1), whose fulcrum is the row-lock, and the common balance (2). The amount of amplification of the effort applied to a lever is known as the mechanical advantage; the effort is increased in the same proportion as the distance between the effort and the fulcrum exceeds the distance between the fulcrum and the weight. The balance here is in a state of equilibrium because although the objects in the scale (a) weigh more than the weight on the hook (c),

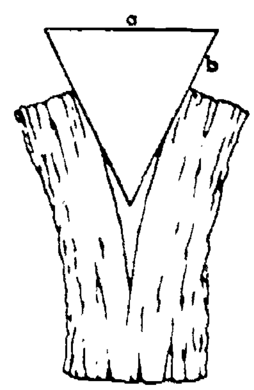






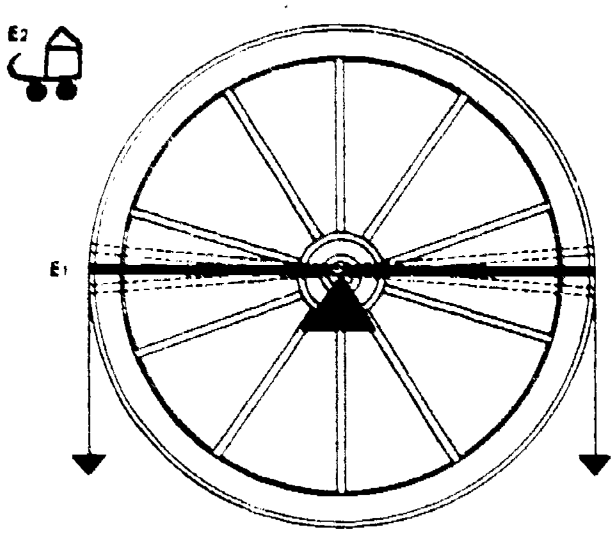
A An inclined plane is a flat surface at an angle to the horizontal. To keep an object (a) in place on an inclined plane, a force is required that is equivalent to the proportion of the object's total weight that the inclined plane's height (b) bears to its length (c), if the force is parallel to the inclined plane and directed towards its top, and if friction is ignored. The weight of an object resting on an inclined plane may be divided into two components, one acting at right angles to, and the other acting parallel to the inclined plane; the force needed to move the object up the inclined plane must exceed that of the parallel component, which gets smaller as the length (c) of the inclined plane exceeds its height (b)—with the simple machines, any decrease in force is accompanied by a reciprocal increase in distance.

B The wedge is based on the same principle as the inclined plane. When a wedge of regular section is driven into a piece of wood, for instance by a force acting at right angles to the wedge's base (a), a force acts at right angles to each of the wedge's sides (b). These forces are together greater than the force acting on the wedge's base in the same proportion as the side of the wedge bears to its base.

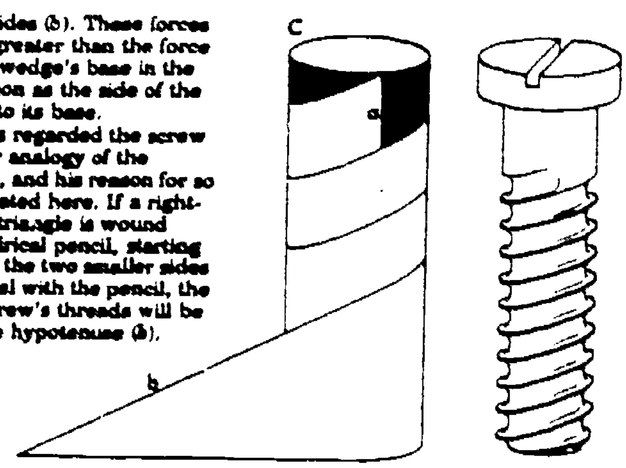


their distances (b, d) from the fulcrum (e) are in inverse proportion to their weights.

E The wheel (1) can be regarded as a one-armed lever capable of rotating through 360° round a fulcrum that is the axle. One of the oldest known illustrations of a cart with wheels (2) is part of a Sumerian pictograph, which has been dated to c. 3500 BC.



C Archimedes regarded the screw as the circular analogy of the inclined plane, and his reason for so doing is illustrated here. If a right-angled paper triangle is wound round a cylindrical pencil, starting with one (a) of the two smaller sides running parallel with the pencil, the pitch of the screw's threads will be marked by the hypotenuse (b).

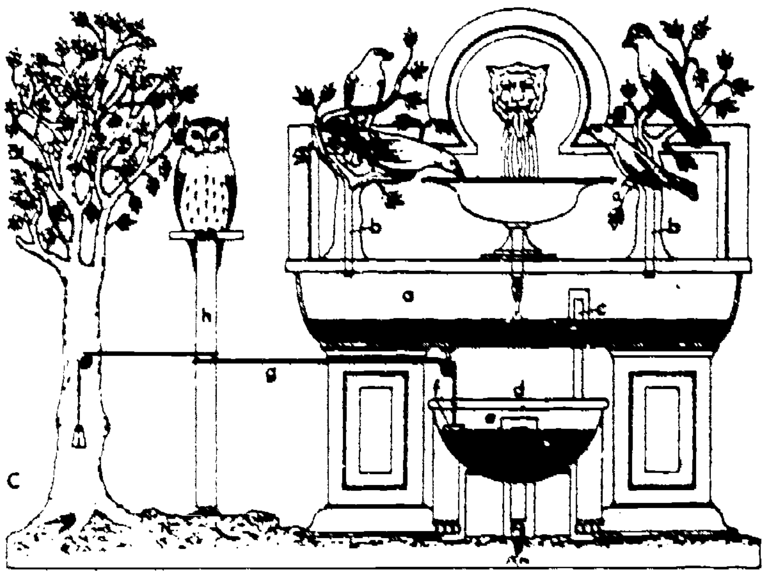


More often than not, though, the inventions of the Alexandrian philosophers were not more than toys which were made to illustrate a scientific principle or to delight other people.

C Hero's singing birds. Water flows from the lion's head into a covered container (a). Air is then forced out of the container through pipes (b), leading to whistles inside the birds. When the water level rises above the top of a pipe (c) covered by a cope—which lets in water at its lower end and is mounted with its top slightly above the top of the pipe—the pipe and cope together work as a siphon, and the water is emptied from container a into another container (d). A similar siphon arrangement (e) is built into this container, which also contains a float (f) to which a rope (g) is tied. The rope is wound once round a rotating pillar (h) and carries a weight (i) at its other end. When the water level—and, thus, the float—rises in container d, the pillar with its owl rotates until the water level has risen so high that the siphon starts working, and the container is emptied of water. The float then sinks, and the owl rotates back to its original position.

Hero was a particularly inventive scientist. His experimentation with steam led to the invention of the "aelopile," which converted heat into mechanical energy by means of expanding steam. It never became anything more than an amusing plaything. Some of the clever devices invented by Hero are described by Strandh:

> One of the best known and most ingenious of his automatic devices is the one by which the doors of the inner sanctum of a temple were opened by the lighting of a sacrificial fire on a nearby altar. This must have seemed miraculous to the uneducated and illiterate members of the congregation, who undoubtedly believed that this was tangible proof of the almighty power of the gods.
>
> ...toy birds...were made to sing by a mechanism powered by a water-wheel, and the crown of dancing figures, rather like a modern angel chimes, which was driven by a heat turbine. These should not be dismissed out of hand just because they were built for pleasure. After all, those principles of natural law that Hero and other engineers of the Alexandrian school were demonstrating....came to play a significant role in the future development of science and engineering. (*A History of the Machine*, page 33)

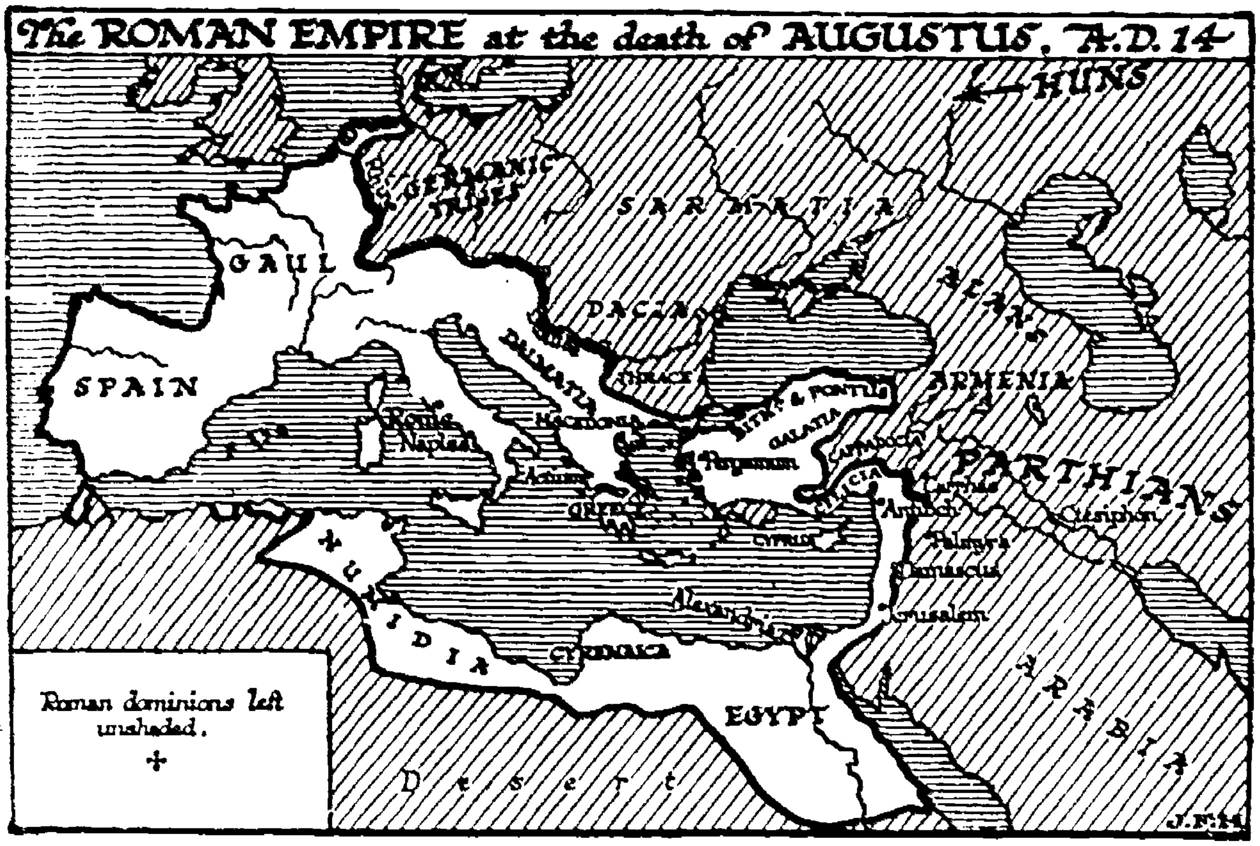


Two thousand years after the time of Hero, an instrument maker from the University of Glasgow in Scotland put Hero's engineering accomplishments to work. The steam engine of James Watt,

based on inventions of Hero, provided much of the power of the Industrial Revolution. We will be discussing this revolution in a later lesson.

The Romans Conquer the Greeks

Except for the short-lived empire of Alexander, Greek civilization was not controlled by a central government. For the most part, Greek political organization consisted of independent city-states.



The Romans, who conquered the Greeks and most of the Western world, had a genius for political administration. As they absorbed their neighbors, the Romans built vast networks of roads and bridges to tie their empire together. According to Kirby, The Romans were the foremost engineers of this time. But he goes on to say:

> Unlike preceding periods, the time of Rome was one of few discoveries

or inventions. Romans did little theorizing, but they were skillful at learning and adapting the ideas and practices of others. (*The History of Engineering*, page 57)

The Romans were practical people. They were more interested in the application of ideas than in the creation of new ones.

They were developers rather than inventors. One of their only notable inventions was the development of concrete, which revolutionized the building trades. Even this development was an adaptation of an earlier technology--the use of lime-based cement, which seems to have first appeared in Crete, and later adopted by the Greeks. The Romans developed concrete by mixing cement with sand, gravel, crushed tiles, or volcanic ash.

For four hundred years the Romans ruled most of Europe and parts of Africa and Asia. The impact of their civilization is still being felt today. Many roads, bridges, aqueducts, and other structures still stand, some of them over two thousand years old. Roman techniques for building with concrete are still being used, though the quality of craftsmanship of the Roman structures often exceeds modern standards.

The Roman language, Latin, is still used in the law profession, in religious rituals, medicine, and in other sciences. The alphabet and many words of the English language are direct descendants of Latin.

Caesar Detroys the Alexandrian Museum

The tsars of Russia and the kaisers of Germany, in our own century, took their titles from a dynasty of Roman emperors that began with Julius Caesar. It was Caesar who, forty-seven years

before the birth of Jesus Christ, plundered Alexandria and burnt down the Museum and its library.

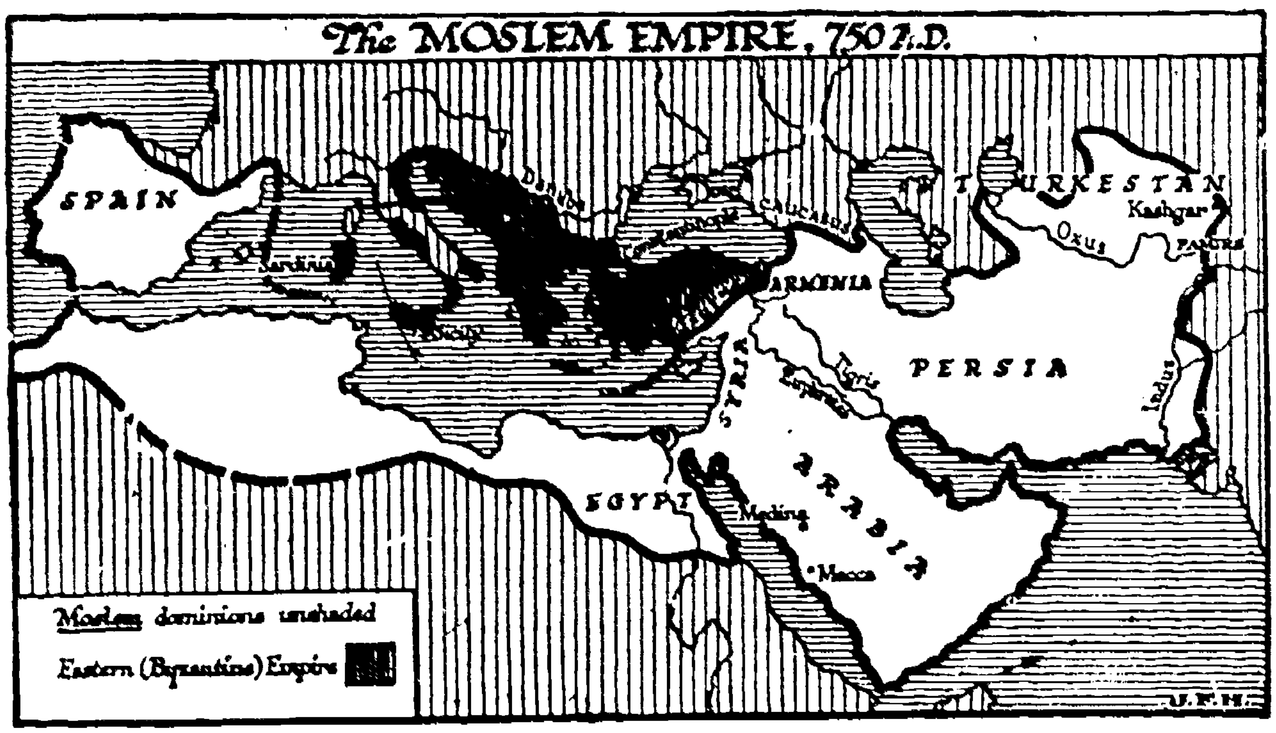
The library had contained about half a million works of science, literature, and art. Our knowledge of these works came to Europe through Arabic translations which were made prior to the time of Caesar.

JVLIVS CÆSAR
(from the Naples bust)

The Impact of Moslem Arabs on Science and Technology

In the Middle East, in an area smaller than the state of California, first the Jewish, then the Christian and Moslem faiths began. The similarities of these religions far exceed their differences. All claim Abraham as their original ancestor. All believe in one and the same God, though called by different names.

While Christianity was firmly establishing itself in Europe, the Moslem Arabs carved out an empire in the Middle East.

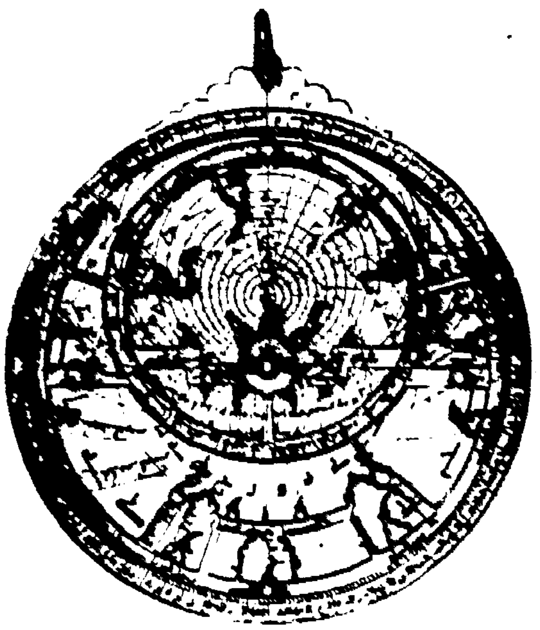


Moslem conquests brought the Arabs into contact with the work of Greek scientists and philosophers. As mentioned earlier, the Romans did little theorizing, but were more interested in the applications of ideas. It was the Moslem Arabs that took up where the Greeks had left off, by adding to the knowledge of the Greeks some of their own ideas and some that they had gathered from the Far East. The Jews also had considerable influence on Arab thought.

Several great Moslem universities were founded in Basra, Kufa, Bagdad, Cairo, and at Cordoba, a century before any were established in Europe. Like the university in Alexandria, the Moslem schools drew scholars from many places.

It was at the Arab universities that Christian Europe learned of all the classics from ancient Greece, the Middle East, and Asia.

The Arabs built on the foundations of Greek mathematics and science. They made great strides in the development of algebra. They invented the pendulum, advanced the physics of optics, and made progress in the science of astronomy. They built several observatories and constructed astronomical instruments, some of which are still in use today.



Astrolabe

One of these instruments, the astrolabe, is a device that measures the elevation of the sun or a star from the horizon. It was used to determine latitude, sunrise, and sunset--revolutionizing marine navigation. This invention was to later enable ships to more easily explore beyond coastal waters--which together with the magnetic compass eventually led to the discovery of the American continent.

In medicine, the Arabs made great advances over the Greeks by studying physiology and hygiene. Their surgeons understood the use of anesthetics and

could perform operations that today would be considered difficult. In chemistry they discovered many new substances such as alcohol, potash, and nitric and sulfuric acids.

They practiced farming in a scientific way, writing several books on the subject. They knew the value of fertilizers and how to graft and produce new varieties of fruits and flowers.

In the world of commerce, they manufactured things of beautiful design and workmanship. Their metal, pottery, textiles, and items made of leather were much sought after.

An astronomer using an astrolabe to measure the altitude of the stars, helped by a mathematician and a clerk. From a painting in an 11th century manuscript.

SUMMARY

The advent of agriculture made possible the establishment of cities. New technologies were developed to support urban society.

As cities were organized into empires, technologies and ideas were exchanged. Within the cosmopolitan city of Alexandria, scientists and other scholars collected knowledge and pursued new ideas. Though the Romans destroyed many of the records kept in the Library, the Moslems kept alive and furthered the achievements of the Greeks.

The roots of modern Western Civilization are deeply embedded in the old civilizations of Egypt, Greece, Rome, and of the Arab world.

In the next lesson we examine part of the role which energy has played in human history, as we shift our attention towards Europe.

COMPLETE THE FOLLOWING WORKSHEET

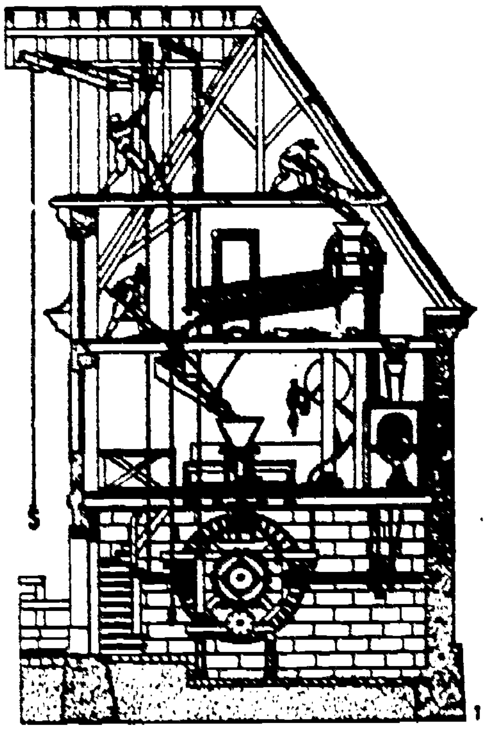
A HISTORY OF TECHNOLOGY

WORKSHEET

Use your notes and the reading material to make an outline of the important concepts presented in this lesson. Write your outline on this page, and then write a short (2-4 pages) summary of this lesson. Use your outline as a guide for writing the summary.

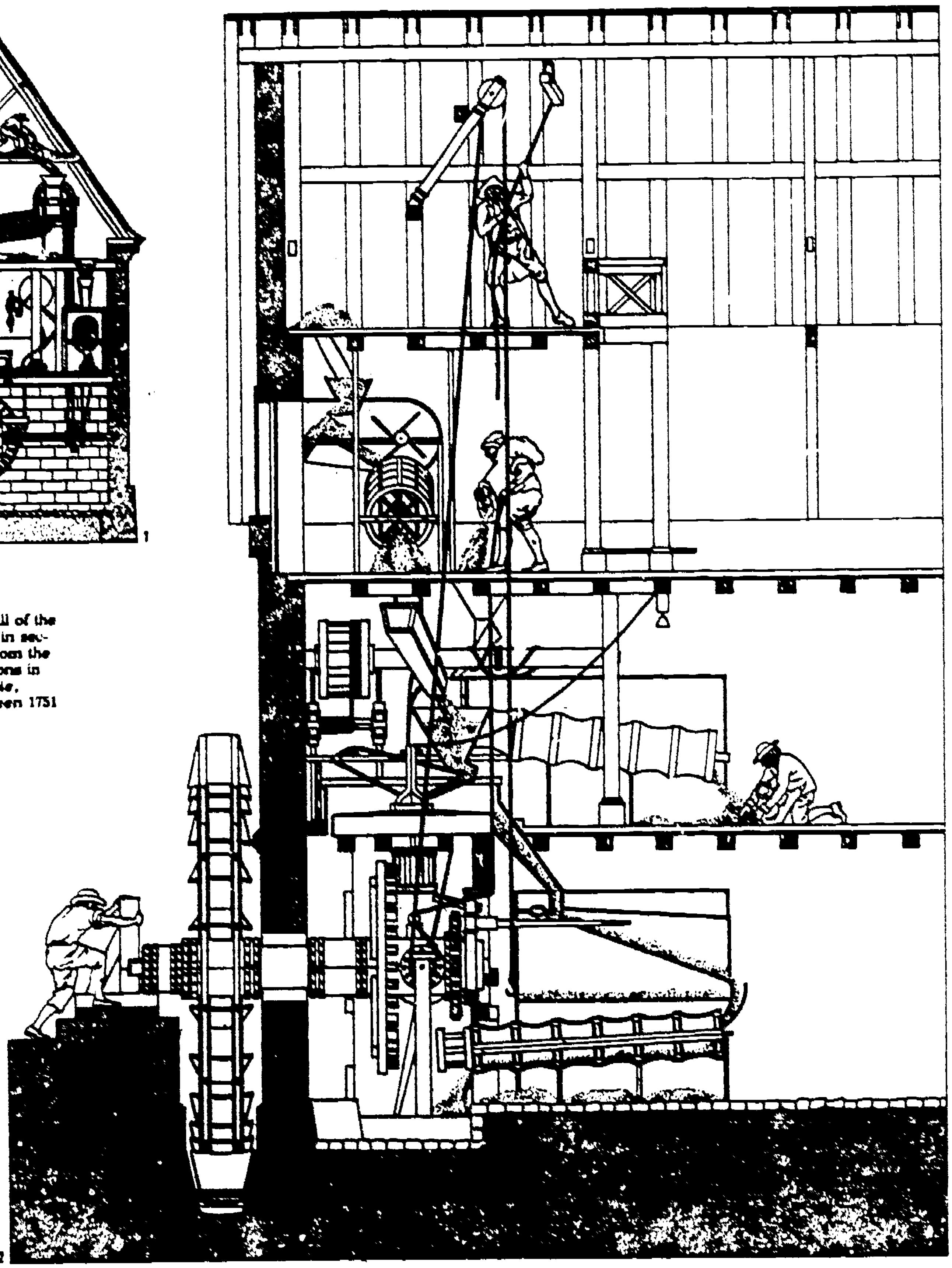
A HISTORY OF TECHNOLOGY

LESSON 3



1

A water-wheel-powered mill of the eighteenth century, shown in section from in front (1) and from the side (2). Based on illustrations in Denis Diderot's ***Encyclopédie***, which was published between 1751 and 1780.



2

A HISTORY OF TECHNOLOGY

LESSON 3

REVOLUTIONS IN ENERGY

The chief glory of the later Middle Ages was not its cathedrals or its epics or its scholasticism: it was the building for the first time in history of a complex civilization which rested not on the backs of sweating slaves or coolies but primarily on non-human power.

Lynn White
Technology and Invention in The Middle Ages

INTRODUCTION

Energy is often defined as "the ability to do work."

Energy exists in many forms. Heat energy, mechanical energy (the energy of motion), chemical energy (energy stored in molecules), light energy, electrical energy, and atomic energy are familiar forms of energy to most of us who live in the 20th century.

Energy can be converted from one form to another.

Consider the mechanical energy that enables a person to walk or that propels an automobile. Where does the energy of motion come from?

The fusion of hydrogen in the sun releases atomic energy which travels as light energy to the Earth in about eight minutes. Plants capture the light and store its energy in sugar molecules

(chemical energy), which can be eaten by people and then converted into mechanical energy by muscles.

The energy which is stored in gasoline originated as the chemical energy of plants.....which came from sunlight.....which resulted from the release of atomic energy. The engine of the car serves a similar purpose as the muscles of a person--it converts the chemical energy into motion.

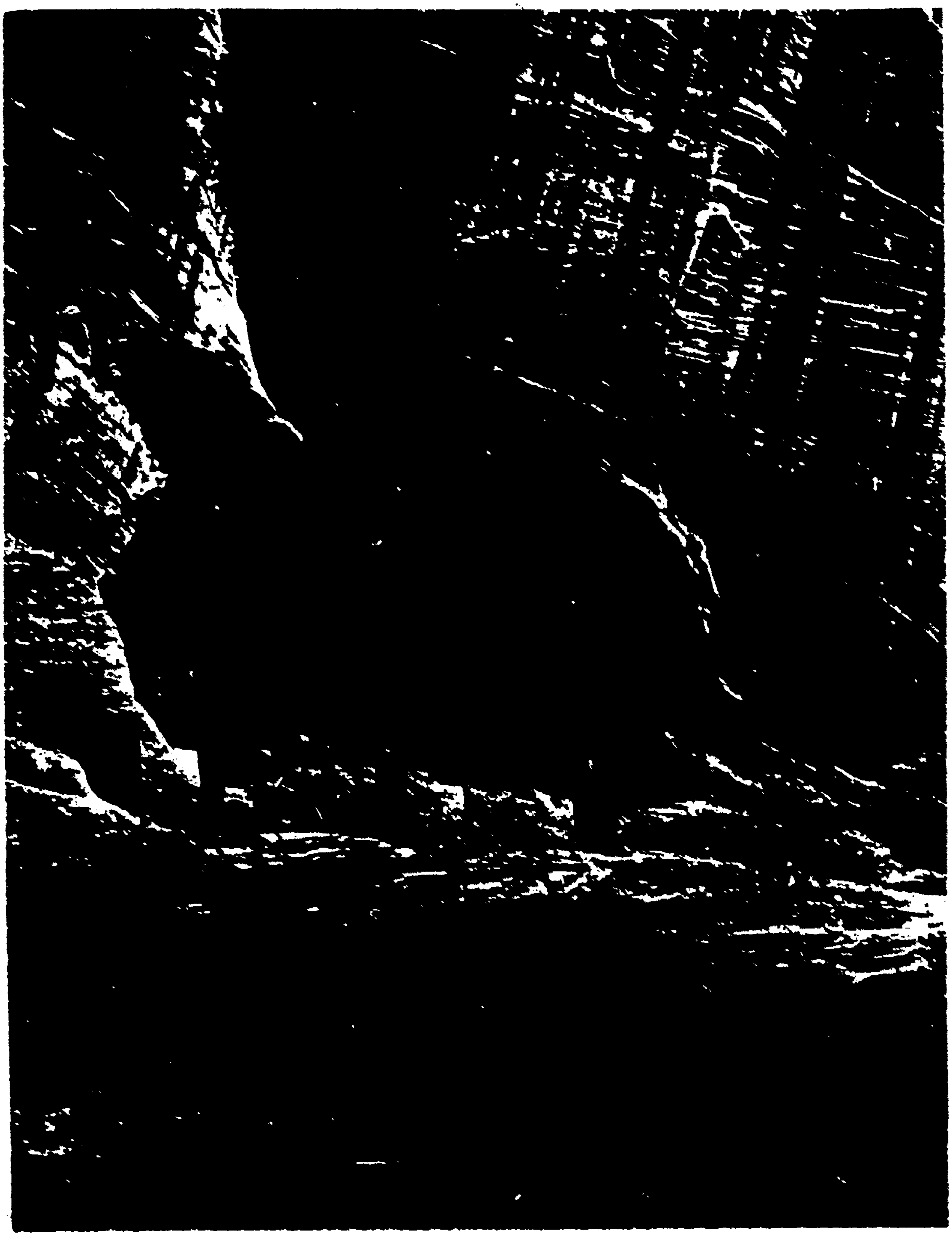
Energy fuels the activities of human society, such as agriculture and industry. Without energy there would be no life as we know it....and no civilization. In this lesson we examine a few of the important developments in the human uses of energy.

REVOLUTIONS IN ENERGY

For millions of years, food supplied most of the energy used by people. With the discovery of fire and the development of technologies to control it, the human species embarked on a new adventure.

The history of civilization is intricately intertwined with the history of energy development.

For 400,000 years wood was a chief source of energy. It continues, today, to be the chief source of fuel for many people throughout the world, and in the United States it currently provides more energy than all of the nuclear power plants combined.



T.H. O'Sullivan's 1873 photograph of the pueblo ruins at Canyon de Chelly, Arizona, called "The White House". An early example of solar technology.

Two Ancient Uses of Solar Energy

The energy stored in wood is captured sunlight. The ancient Greeks and the Anasazi Indians of the United States invented ways to use the energy of the sun more directly.

Approximately 2,500 years ago the ancient Greeks designed their homes and cities to take maximum advantage of the sun's energy, as a source of heat. The city of Olynthus was designed in such a manner that all homes had a southern exposure. Thick adobe north walls shielded the homes from the cold north winter winds. Overhanging roofs shielded them from the hot summer sun which otherwise caused overheating.

About nine hundred years ago the Anasazi Indians of the Southwest United States built their homes in south-facing rock walls under overhanging cliffs. This maximized access to the winter sun and provided shade from the summer sun, much like the solar designs of the Greeks.

Energy in Ancient Rome: Wood, Solar, and Conservation

Wood was used extensively in the Roman Empire. It was used as fuel for industry, to build homes and ships, and for heating.

The Romans were often wasteful of their wood resources. As much as two cords of wood a day were used to heat some of the large Roman houses. A cord of wood is a stack of logs four feet wide, four feet high, and eight feet long.

The wasteful practices of the Romans led to the depletion of the forests on the Italian Peninsula, which was the seat of their empire. They were forced to rely on expensive imported

wood transported by boat from their colonies in France and North Africa. To conserve wood and save money, Roman architects turned to the sun.

They used solar energy to heat residences, bath houses, and greenhouses. They advanced solar technology by adapting building designs to different climates and by using clear window coverings, such as glass, to enhance the effectiveness of solar heating.

The Roman architect Palladius advocated the recycling of bath water and the placement of rooms directly above the hot baths. In this way the rooms benefited from the waste heat of the baths. This is a form of energy conservation.

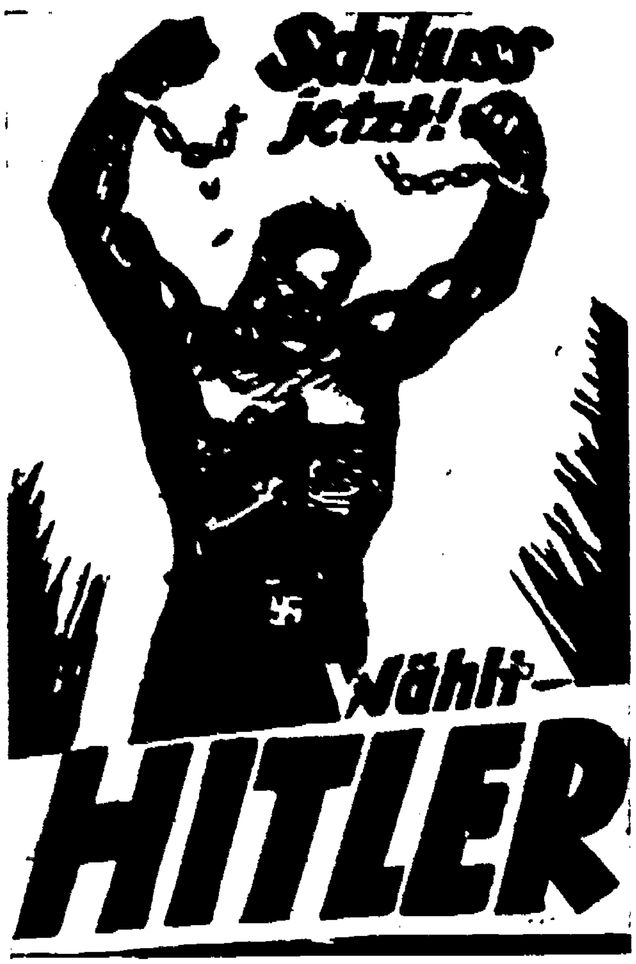
In the second century A.D. (1800 years ago), the Roman jurist Ulpian ruled that access to the sun could not be violated. This meant that citizens of Rome were not allowed to cast shadows on their neighbors' houses, blocking exposure to solar energy. (Similar laws, called "solar access laws," have recently been advocated in the United States.)

A Change in the Attitude towards Slavery

As mentioned in the last lesson, the emergence of cities was accompanied by an increase in human slavery. Slaves were a principal source of power for three thousand years.

It was after the fall of the Roman Empire, during the Middle Ages, that slavery came to be considered as an immoral and unacceptable practice.

It is said that in Europe the spread of Christianity was the prime reason for the changing attitude towards slavery. In other parts of the world,



This Nazi campaign poster calls on the voters to choose Hitler and thereby free Germany from its chains.

the rise of other major religions--Bhuddism and the Islamic faith--had a similar impact.

We should make it clear that the practice of slavery did not end during the Middle Ages. As you probably already know, there were slaves in the United States until the end of the Civil War in 1865. The number of slaves in our country was increasing just before the Civil War because of the worldwide demand for cotton during the Industrial Revolution. In 1790, just after the beginning of the Industrial Revolution, there were 700,000 slaves in the United States. By 1860 there were nearly four million.

During World War II, the Nazi government of Germany herded millions of people into slave labor camps. Some of these people were forced to make military weapons for their masters. Others labored in factories which efficiently destroyed several million other people.

New Sources of Power

During the Middle Ages new sources of power were developed in Europe: water, wind, and horses. New machines were invented or introduced from other places to utilize these new sources--the water wheel, windmills, sails, and devices to make the horse a more effective source of power.

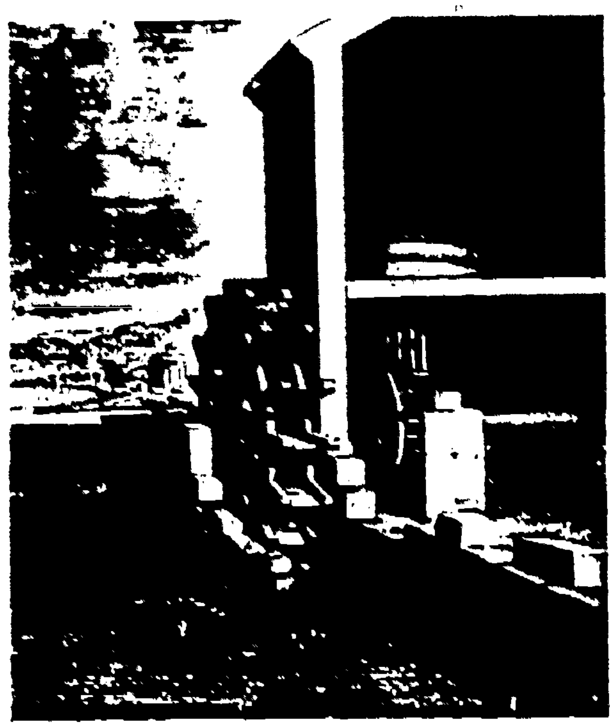
The technological developments which are described in this lesson played a major role in setting the stage for the Industrial Revolution.

Water Power

There is some evidence that water wheels were first used in India. The Romans introduced them to Europe during

the last centuries of their empire. By the eleventh century (about 1000 years ago), water wheels were powering machines to grind flour, operate saws, move the bellows of forges, pump water out of salt mines, and to power breweries and factories.

The first water wheels were probably paddlewheels driven by river currents, and used to raise water for irrigation or for some other use. These wheels are similar in design to the fishwheels used on many Alaskan rivers to catch salmon.



Flour mill and undershot water wheel (From Perrault, *Vitruve*, 1684)

Later designs took advantage of the tidal action of water, such as the one used at the London Bridge. Others, called overshot water wheels, took advantage of the height of water sources, such as waterfalls. The overshot wheel proved to be the most widely used because it developed the most power.

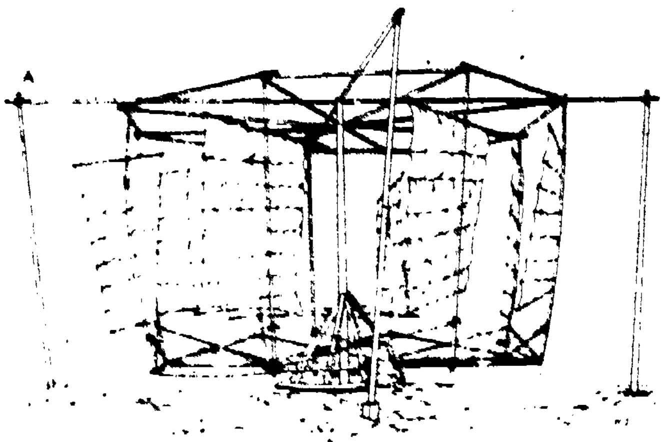
Wind Power

The power of the wind was probably used in prehistoric times to propel simple boats. The first sails might have been made by weaving branches together or from animal skins, but the art of cloth-making is ancient and cloth sails were known to the Sumerians in 3500 B.C.

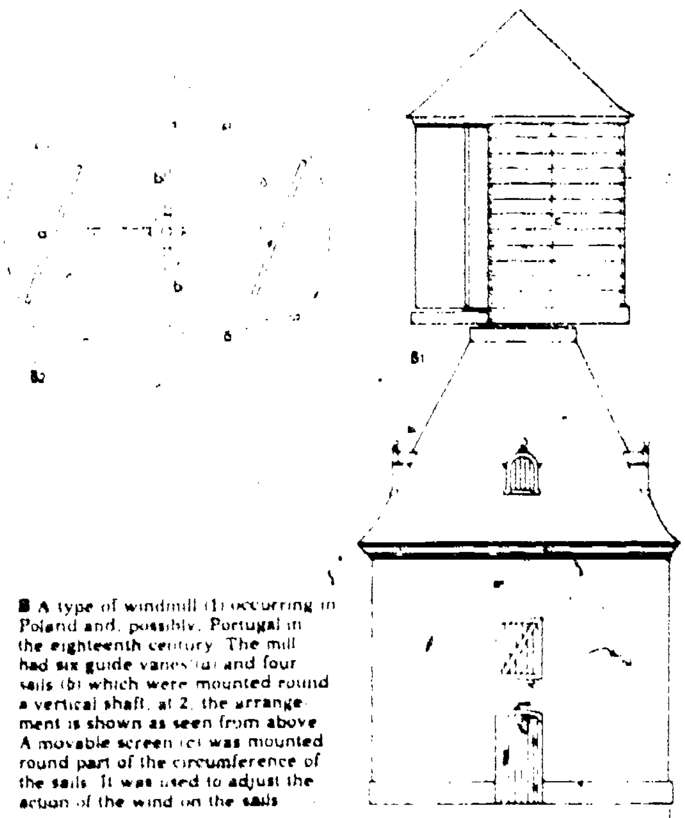
As early as the time of Christ, Northern Europeans were building ships with square sails, but most large vessels were powered by gangs of slaves pulling long oars. The art of rigging sails on fairly large ships was well developed in the Mediterranean world, but it was not until the seventh century, when the "lateen sail" was brought to Europe by Moslems from Southwest Asia, that the widespread use of sailing vessels occurred.

Greek ships were using the lateen in the ninth century, and so did the ships of the eleventh-century Italian cities. Once the Mediterranean merchantman was equipped with the lateen it no longer required oars. After the twelfth century the fore-and-aft lateen rig began to be used on all European coasts. In the fifteenth century the lateen sail was combined with the Northern square rig and it was with this combination rig that the great adventurers explored the world in the last of the fifteenth and early sixteenth centuries. These new rigs increased the distance which a ship could travel by materially reducing the size of crew, more than doubled the speed of the ship, and relieved men from the heavy drudgery of rowing. (*The History of Engineering*, page 101)

A In China, this type of vertical-shaft mill is still used in combination with a chain-pump for irrigation and for pumping brine into salines. The sails look very much like the sails on a junk, and it seems probable that the construction used to be built of bamboo poles.



The windmill was another major wind-powered device to come into popular use during the Middle Ages. There are still windmills in Greece today which combine the lateen sail and a tower to produce a wind motor.



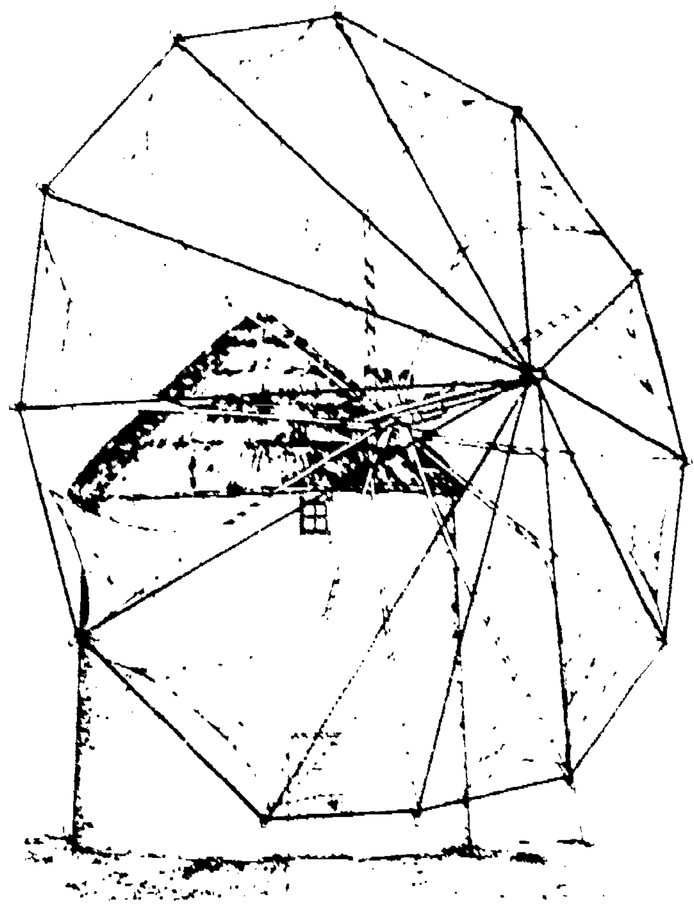
B A type of windmill (1) occurring in Poland and, possibly, Portugal in the eighteenth century. The mill had six guide vanes (a) and four sails (b) which were mounted round a vertical shaft; at 2, the arrangement is shown as seen from above. A movable screen (c) was mounted round part of the circumference of the sails. It was used to adjust the action of the wind on the sails.

The windmill probably originated in Persia (Iran) in the tenth century (about 1100 years ago). The design for the Persian windmill is said to be taken from a wind-driven prayer wheel of central Asia.

It was not until the twelfth century that windmills appeared in Europe. Early ones had horizontal axles with vertical sails and were necessarily small because the entire mill had to be rotated to bring the sails into the wind.

By the fifteenth century the so-called bonnet windmill was invented, which made possible the construction of much larger mills because it was only necessary to move the bonnet at the top to place the sails into the wind.

As with the water wheels, the windmills powered various types of machines. They were particularly popular on the plains of nortwestern Europe where there are not many natural waterfalls or rapidly flowing rivers.



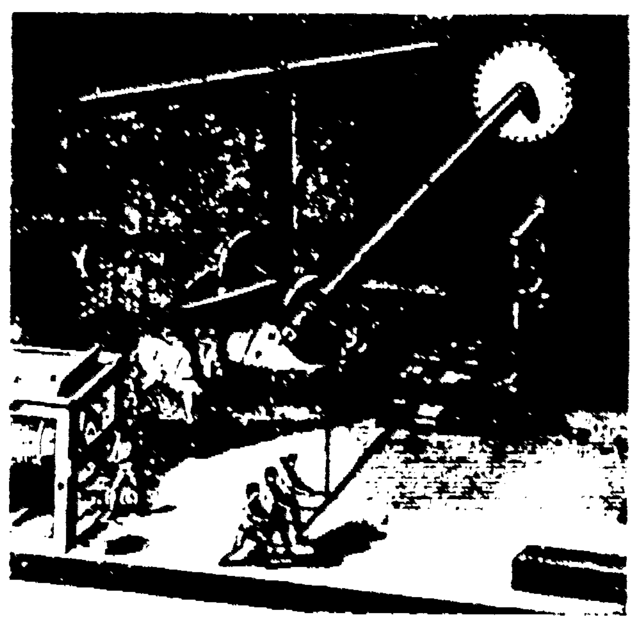
Tower-mills with eight to twelve lateen-type sails are still a typical feature of the Aegean landscape. The origins of this type of mill are not known, but it is thought that it was inspired by the tower mill which came into use in western Europe in the fourteenth century.

Horse Power

A type of yoke which was used by the ancient Greeks and Romans strangled the horse if it pulled too hard. At the end of the eighth century, the oval horse collar was introduced to Europe from China. The Chinese had already been using it for 1100 years.

The oval collar allowed horses to pull with their shoulders instead of their necks. This one innovation multiplied the horse's ability to pull by three to four times.

While the new collar was spreading throughout Europe, the iron horseshoe came into use, further increasing power output by giving the horse better traction. The iron horseshoe also prevented hooves from splitting and breaking under the strain of heavy loads. The invention of the tandem harness allowed several horses to be hitched together to pull a load.



These new technological devices paved the way for the adaption of horses to a multitude of tasks. Horses proved to be valuable sources of power for agriculture and for the operation of machines.

The strength of the horse is still a standard measurement of ***power***. The word "power" is used *informally* to mean "energy available for work." It also has a *technical* meaning. When used technically, it is a measure of the *rate at which energy is produced*. We will be discussing some technical aspects of energy in future lessons.

The average power a slave can exert by muscular effort has been estimated to be 1/20th of a horsepower. An automobile, at 100 horsepower, is equivalent to the power developed by 2,000 slaves. A four-engine jet airplane, at 35,000 horsepower, is the power equivalent of 700,000 slaves.

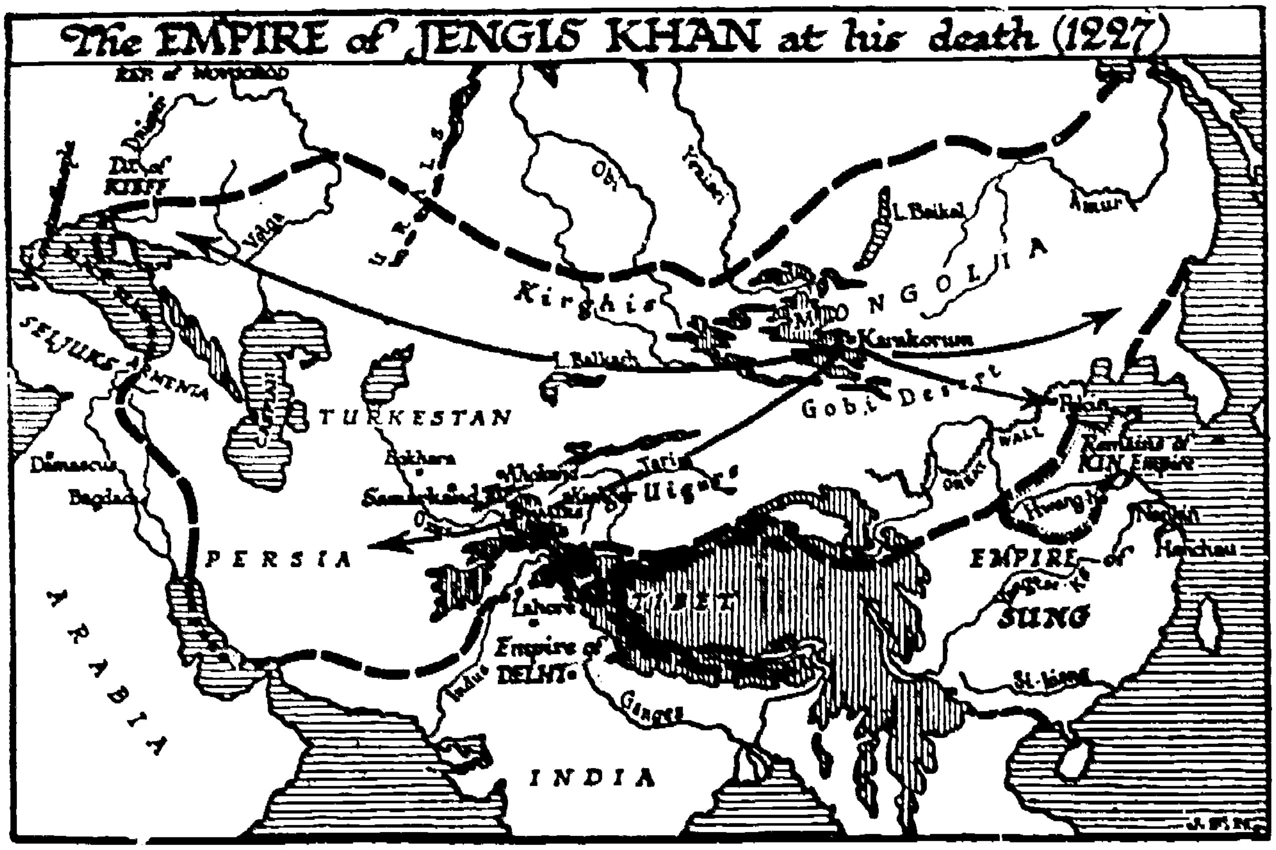
Warriors on Horseback/East Meets West

The horse played another important role during the Middle Ages. It was on horses that the nomadic Mongols under the leadership of Genghis Khan swept across the continent, raiding and subjugating every civilization in its path, from China in the East to the European borders in the West. The Mongols were descendants of the people who first bred and rode horses in about 2,000 B.C. in Asia.

> We cannot hope to recapture today the terror that the mounted horse struck unto the Middle East and Eastern Europe when it first appeared. That is because there is a difference in scale which I can only compare with the arrival of tanks in Poland in 1939, sweeping all before them. I believe the importance of the horse in European history has always been underrated. (*The Ascent of Man*, page 80)

The effect of the Mongolian conquest in diffusing and broadening human ideas can be compared to the spread of Greek civilization by Alexander which occured fifteen hundred years earlier. The Mongols essentially brought Eastern and Western civilizations together for a short time.

It was during this time that the famous Venetian traveler, Marco Polo, visited the great Mongol leader, Kublai Khan, in China. After returning to Europe, Polo dictated his experiences to



a fellow prisoner named Rusticana. Together they wrote one of the most famous books of Western literature, describing Polo's travels in the East and the wealth and marvelous inventions he had seen there. *The Travels of Marco Polo* captured the imagination of many European adventurers and spurred them on to further exploration of the world.

In a later lesson some of the Asian influences on European culture will be discussed further.

The Influence of Wood in Europe

A visitor to Europe today is likely to be impressed with how well used every available space is. Everything appears to be partitioned into neatly arranged geometric sizes and shapes. Even the open spaces have a measured look to them suggesting that the whole continent was meticulously planned out and sculptured down to the very last detail way back at

> the beginning of time. It would be difficult to imagine that in the fourth century the continent was a blanket of dense forest.....A bird could fly over the treetops for hundreds and hundreds of miles seeing only an occasional clearing. In some of these tiny open spaces a little smoke might be coming from an open fire. Nearby, there might be a few thatched huts and twenty or thirty people scurrying back and forth near the edge of the forest. (Jeremy Rifkin, *Entropy*, page 71)

Like fossil fuels of today, wood was used for just about everything in Europe during the Middle Ages. Lewis Mumford sums up the importance of wood to the people of this period, by observing that "as raw material, as tool, as machine, as utensil and utility, as fuel, and as final product wood was the dominant industrial resource."

Wood Becomes Scarce

During the Middle Ages, in part due to improved agricultural technologies, the human population of Europe steadily increased. Consequently, the need for wood increased, as did the need to grow more food. Competing uses of limited land put a strain on the wood resource. The growth of new industries, fueled by wood, added to this strain. Jeremy Rifkin describes the situation:

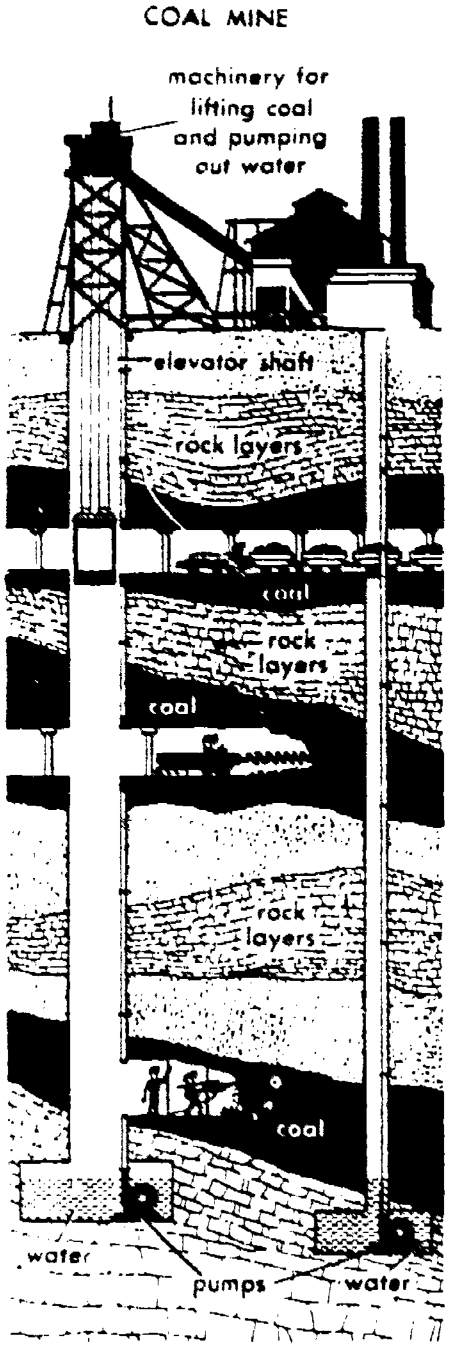
> While the clearing of forests for cultivation greatly reduced the available wood supply, it was the quickened pace of commercial activity that led to a timber famine. For example, the new glass works and soap industry required large amounts of wood ash. But it was the production of iron and the building of ships that made the greatest demands. By the sixteenth

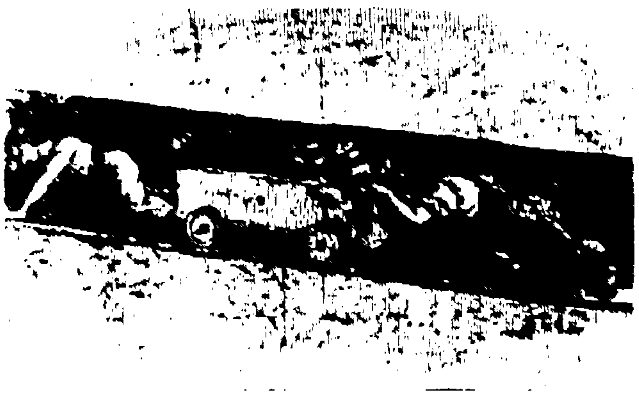
and early seventeenth centuries, the timber crisis was so acute in England that royal commissions were set up to regulate the cutting down of forests. The regulations proved ineffective. In the 1630's wood had become two and a half times more expensive than it had been in the late fifteenth century. (*Entropy*, page 74)

Coal: A Replacement for Wood

The wood crisis in Europe of about 800 years ago was in many ways similar to the world oil crisis of the 1970's. The solution found by the people of the thirteenth century is a solution often presented by energy experts today: *coal*.

The answer to the wood crisis was coal. But it was not just a simple matter of replacing one energy base with another. The cultures of Europe had been thoroughly integrated into a wood-based existence. The changeover necessitated the radical uprooting of an entire way of life. The way





people made a living, the way people got around, the way people dressed, the way people behaved, the way governments governed--all of this was turned inside out, then upside down.

It started in England in the thirteenth century under [King] Henry II. The people of Newcastle were without firewood and literally freezing to death. The king consented to the mining of coal as an alternative energy source.

In the fifteenth century, Pope Pius II wrote that while in Scotland on a visit he was surprised at the sight of people in rags lining up at church doors to "receive for alms pieces of black stone with which they went away contented. This species of stone they burn in place of wood of which their country is destitute." By 1700 coal had begun to replace wood as the energy base for England. Within 150 years the same held true for much of western Europe.

Today we think of the substitution of coal for wood as a great leap forward, a singular triumph for the forces of progress. It would have been difficult to convince the folks back then. Coal was treated with contempt as an inferior energy source. It was dirty and created a great deal of pollution......

Coal was also more difficult to extract and process than wood. It required the expenditure of a great deal more energy to transform it into a usable state. (*Entropy*, page 74)

As you will learn in a future lesson, the steam engine was first put to use to pump water from coal mines. This invention played a central role in

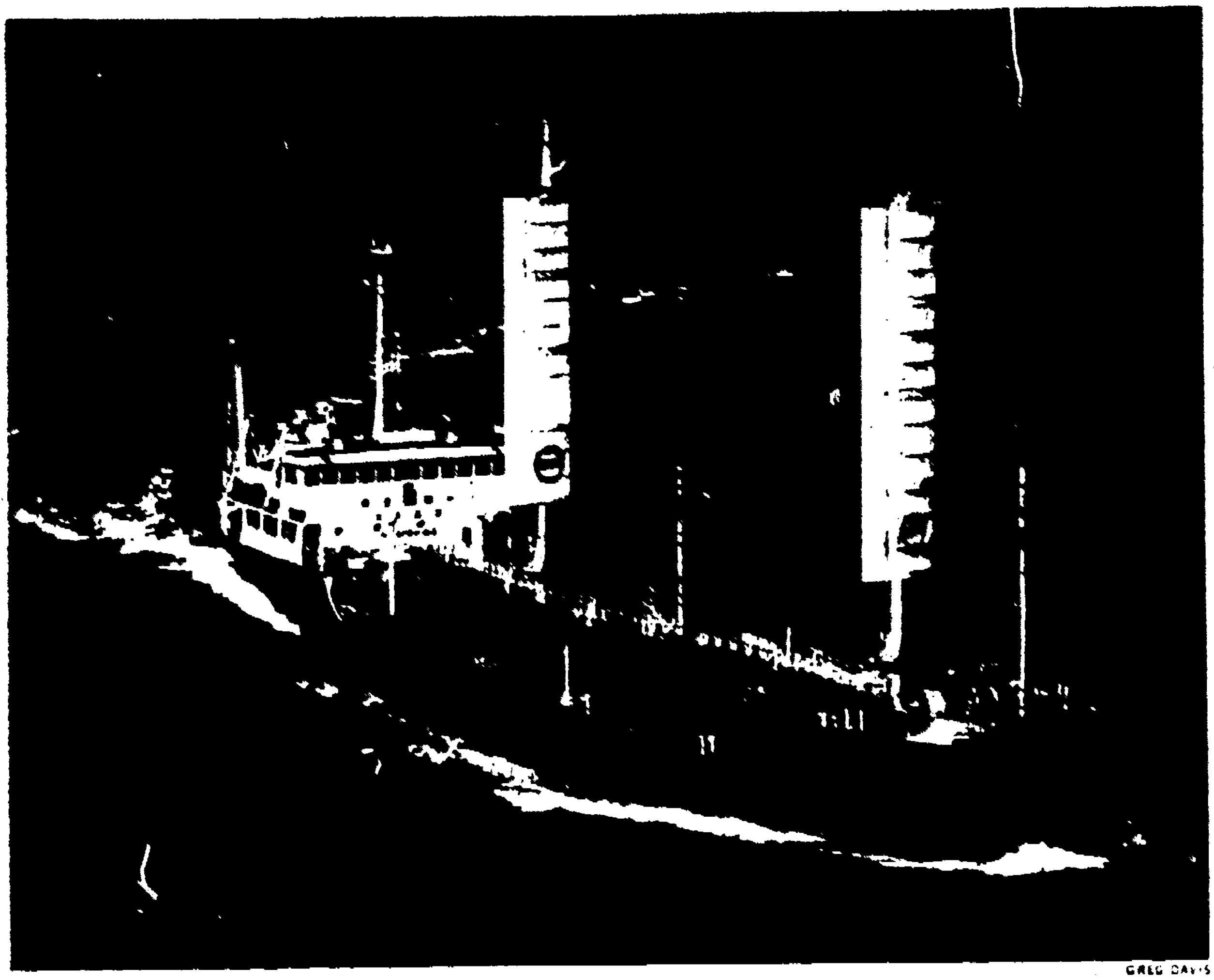
The Corliss steam engine at the Centennial Exhibition (From Harper's Weekly, May 27, 1876)

the beginning of the Industrial Revolution.

Oil, Natural Gas, and Atomic Energy

In later lessons we will complete this history of energy-use, when we examine the development of oil, natural gas, and atomic power as sources of energy.

COMPLETE THE FOLLOWING WORKSHEET.



GREG DAVIS

HARNESSING THE WIND

IT LACKS halyards, sheets, shrouds, and most of the rigging that ships used in the past age of commercial sail. Yet the Japanese "Shin Aitoku Maru" (**above**) is the prototype of what may be a new fleet of sail-aided cargo ships. The incentive: Japan's acute need to conserve imported oil, the same oil that ships carry as cargo.

In a 30-knot wind abeam, the sails on the fully loaded ship can provide 53 percent of the power to travel at 12 knots. To get the most from other wind speeds and points of sail, a microcomputer system gives automatic commands to trim the steel-framed canvas sails by rotating the masts. In a fair and strong wind, the engine slows down automatically. Otherwise, the engine works no harder than necessary to maintain constant ship speed. With efficient equipment and design, fuel savings can be as high as 50 percent.

Wind is secondhand solar energy; its basic driving force is the unequal heating of the earth and atmosphere. It is given characteristic flow patterns by the earth's rotation.

As every sailor and kite flier knows, winds constantly shift in direction and vary in speed. Although utilities would have to learn to accommodate the variable outputs of wind machines, researchers believe wind power could become a continually useful source of energy.

Its availability depends on geography. Wind generators are most practical in the Great Plains, in mountains, and along certain coastal areas. One scheme uses 200-foot-high tetrahedral wings moving around a circular track on wheels coupled to generators.

The Wind Energy Systems Act of 1980 has initiated an eight-year, 900-million-dollar program to develop cost-effective wind-power systems in the United States, and a number of large wind turbines are already in the experimental testing or development stages. But it would take 30,000 large turbines and thousands of smaller ones to supply 10 percent of the nation's electrical power needs by the year 2000.

Small windmills can be used by individuals; in 1920 perhaps a million were in use in the U. S., mainly on farms. Denmark alone had about 25,000 in the 1890s. After the horse, ox, and himself, man's primary mechanical energy source before the industrial revolution was wind. It has a role to play again.

A HISTORY OF TECHNOLOGY

WORKSHEET

The emphasis of this assignment and also of the next lesson is to apply what you have learned. You will be using your newly gained knowledge to examine your own dependence on energy.

Several of the concepts which you are expected to use to complete this worksheet have been only briefly dealt with in this course, so far. There is a reason for this. To frustrate you is *not* the reason!

We want to let you think for yourself, before we present more ideas concerning energy-use.

1) Why is energy important for human society?

2) What is your opinion concerning the practice of using human slaves as a source of power?

3) List all of the sources of energy which were mentioned in the reading material of this lesson. Circle the energy sources which are renewable.

4) Both the Romans and the Europeans faced an energy crisis when their wood resources were depleted. Describe two solutions which the Romans used, and one which the Europeans used to deal with their crises.

5) What were some of the causes of these two energy crises?

6) Wood is a ***renewable*** resource. Potentially it is also a ***sustainable*** source of energy. What is the difference between the terms "renewable" and "sustainable?" You might want to use a dictionary to help you answer this question.

7) Obviously the Romans and Europeans did not manage their renewable wood resources in a sustainable fashion. What could they have done to make wood a sustainable resource? [You might want to consider *population size* as a factor in your answer.]

8) The Europeans chose to replace wood with coal. While wood is renewable, coal is not. Renewable resources have the potential of being sustainable, but it is impossible for a non-renewable source of energy to be sustainable.

Do you see any problems associated with reliance on non-renewable energy resources? If so, why, and how can these problems be overcome?

9) What are the sources of energy on which *you* depend? Are they renewable or non-renewable?

Consider the energy used to manufacture and transport the products which you buy, in addition to the energy which you use at home or close to home.

Also, take into consideration the energy used by your local, state, and federal governments to provide you with services (such as roads, coordination of the economy, and protection provided by the military).

A HISTORY OF TECHNOLOGY

LESSON 4

The Christian Science Monitor

A HISTORY OF TECHNOLOGY

LESSON 4

A MOMENT IN THE FUTURE

By the end of the century, we could be looking down the muzzle of a gun.

Sir David Barran
Shell Trading Company
(speaking about the Middle East oil industry)

Those who cannot remember the past are condemned to repeat it.

George Santayana
philospher (1863-1952)

INTRODUCTION

Time for a change of pace! Today, relax the tightness of your muscles which are positioned towards the past. Flex them momentarily into the future.

As you work on this lesson, keep in mind the originality of the Greeks and Moslems. It is the creative spirit of forging ahead into new territory that is needed to understand this lesson.

THE FUTURE IS UPON YOU

Consider the following imaginary, yet plausible, situation:

It is 1995. The international economic crisis of the early 1980's has

been over for eleven years. Industrial growth of the 1990's has far outstripped even the impressive growth of the 1960's.

The Middle East oil-fields are producing oil at record rates, with prices close to the depressed levels of the 1980's oil glut. (During the early 1980's, there was a decline in the demand for oil--for two reasons: the international economy slowed down (recession) and the use of energy-conservation measures increased. As a result, for a while more oil was being pumped from oil-wells than was being bought--creating an "oil glut." Because of the oversupply, the price of oil dropped.)

As the last few salmon of the 1995 season struggle upstream, an article appears on the third page of a Fairbanks newspaper. It is a brief article about the imprisonment of a religious leader by the king of Saudi Arabia. The article receives little attention.

The following day, newspapers in Fairbanks, Anchorage, and Juneau feature second-page articles about an assassination attempt on the life of the Saudi king. A few eyebrows are raised over coffee, as Alaskans read their morning papers.

Headlines of the next day catch a bit more attention. The Saudi oil-fields have been sabotaged. The Persian Gulf has awakened to flames spreading over its tropical waters, as the shimmering desert sun rises above a smoky horizon.

The war which had first broken out in Iran in the 1970's, and had developed into a war between Iran and Iraq in the 1980's, was making its way into the rich oil-fields of the Gulf.

Another Oil Crisis

In the following weeks, oil prices soar while supplies fall. Industry does not grind suddenly to a halt, but slowly starts to feel the effects of the prices and shortages.

Several out-of-print books about the 1973 Oil Crisis appear on newsstands, in response to a revived interest in those long-forgotten days.

Mexican oil development, still plagued by the massive national debts faced in the 1980's, has not yet recovered from the earlier international economic crisis. The effect of Mexico's *nationalization* (government take-over) of the banks in 1982 is still a point of controversy amongst economists.

The end of the conflict in El Salvador in 1985 and the successful liberation of Guatemala's peasants in 1992, just across the border from the Mexican oil fields, is generally believed to have politically stabilized the region. Future oil development in Latin America is likely to be rapid.

In the United States, fortunately, the oil-fields which were discovered off the coast of California in 1982 had proved larger than originally predicted, and are already producing enough oil to supply the West Coast.

Alaskan oil is still flowing from the North Slope, though production has already begun to slow down. Most of it is being shipped to Japan, due to the negotiations in 1985 between Japan's Prime Minister, Yasuhiro Nakasone, and the U.S. Secretary of State, George Shultz. As part of the negotiations, Japan agreed to limit its sales of fuel-efficient cars to the United States.

Changes in the Alaskan Economy

The oil-fields of Alaska had lost much of their prominence in world trade during the 1980's, but the current crisis has brought renewed attention to the still plentiful reserves of oil, natural gas, and coal in Alaska.

Life in Alaska has changed since the heyday of $1000 dividend checks and high-paying state jobs. Stories are still told of the late 1970's, when there were less than half a million people in the state, sharing the enormous oil wealth.

Now, in the 1990's, the total income for Alaska is about equal to the oil income of 1979, but the sources of income have changed, and there is a much larger population to share the wealth.

Economic diversification, which means the development of a variety of businesses, considerably changed the economic system in Alaska during the late 1980's. Fish, barley, minerals (including coal), and high-technology products from the Susitna "Silicon" Valley all contribute to a growing trade relationship with the Pacific Rim countries—most notably Japan and South Korea.

The Influence of Energy in Alaska

The combination of a larger Alaskan population, new industries, and inefficiency has caused a large increase in the amount of energy used within Alaska. There is less available for export. Coal exports to South Korea and Japan have started to grow, but do not equal the losses due to the slowing of oil production.

The lack of energy efficiency in Alaska in 1995 is a condition found throughout the industrialized countries,

resulting from the cheap price of oil during the past eleven years. It has been cheaper to use more fuel than to invest in energy-saving technologies.

Oil prices have been at the root of many other features of the Alaskan economy. Most energy experts agree that if the price of oil had been higher during the past ten years, coal exports from Alaska would have skyrocketed long ago.

Now, as once again the soaring price of oil is bringing great wealth to Alaskans, the rest of the nation looks longingly to the north for help.

Enter: The United States Government

By early winter of 1995, as the need for heating-fuel increases throughout the lower 48 states, the U.S. Federal Government has begun to mobilize. The Department of Energy (DOE) has been resurrected from its demise during the second term of the Reagan administration.

The new DOE officials are attempting to secure energy resources for equal distribution thoughout the country. There is concern that shortages will soon be severe enough that people in some areas might not have fuel to heat their homes. The Strategic Petroleum Reserve of the military lends a sense of security, but can not be easily given up by the Department of Defense.

One DOE official is on his way to meet with the governor of Alaska, to enlist her aid in stimulating an increase in Alaskan oil production, and in cutting back on the use of energy within Alaska. Since the 1970's, energy-use in Alaska has been more than twice as great, measured on a per-person

basis, than the rest of the United States.

The DOE official had been briefed by his superiors before boarding the plane for Alaska. He was made aware of a bill before Congress.

Some of the leaders in Congress are attempting to *nationalize* the U.S. oil industry. This would put the control of oil entirely in the hands of the federal government.

The Past Remembered

Nationalization of the oil industry is not a new idea. Since the turn of the century, many countries had done so.

During World War II, there had been an effort within the United States government to buy a controlling interest of the oil industry. Some of President Franklin D. Roosevelt's advisers, with his support, had made an effort to do so, but had been stopped by the private oil companies.

In the early 1900's, with the forceful prompting of Winston Churchill, the British were able to buy a large part of the Middle East oil industry. But they were not happy several decades later, when some of the Middle East countries wanted a larger role in developing their own resources--and a larger share of the profit.

In 1951 the British government had called upon the United States government to bail out their Middle East oil interests in Iran. A newly elected Iranian leader, Dr. Mohammed Mossadegh, had nationalized the British-controlled oil-fields within Iranian borders, with the full consent of the Iranian government and officially approved by the royal family.

The United States government, with the expert and well-planned help of the CIA, was able to dislodge the massive support of Mossadegh. The Iranian government retained ownership of the oil industry, but when the British were allowed back to run the operation, they were accompanied by new partners--oil companies from the United States.

Now, in 1995, as both the British and the Iranians had done much earlier, a few members of the U.S. Congress are attempting to gain greater control over the strategically important oil industry.

DOE Official Arrives in Alaska

After spending two very pleasant evenings in Alaska, one in Ketchikan and one in Yakutat, the DOE official arrived in Juneau to meet with the first woman governor of Alaska.

He was rather pleased that the weather had been foggy at the Juneau airport for two days, giving him an opportunity to enjoy the hospitality for which Alaska is so well known. The few hours of daylight had been enough to convince him to plan a trip for the following summer, to bring his family to visit this beautiful state.

A Tense Meeting

The new secretarial robot was quiet--too quiet. The governor missed the pleasing hums and whirrs of disc drives, now replaced with accurate and efficient bubble-memory units. She had rather enjoyed the old days, when robots had seemed like clumsy children, needing attention and care. She did appreciate the new software, though, which instantly made the robot into an expert energy consulant. As she was thinking

these thoughts, the DOE official arrived.

After the usual introduction and comments about Alaska's beauty, the seriousness of the meeting was abruptly approached by the DOE official.

"With due respect for your recent efforts, governor, I believe that the State of Alaska must do more to help alleviate the current problems facing the rest of the nation. If you don't act swiftly, Congress is likely to take away much of the present authority which your state government holds.

"Certain key members of the Senate Energy Committee have endorsed a bill calling for nationalization of the U.S. oil industry. Congressional hearings will begin within a week.

"Your state's use of oil has been noticably out of line with that of other states, and members of Congress, especially those from the Northeast, have decided that Alaska can no longer get away with such blatant over-use of our dwindling oil supply. They also object to the State of Alaska making money on the sale of oil and natural gas to foreign countries, when the rest of the United States is suffering as a result.

"What steps is Alaska willing to take to solve these problems?"

The governor paced back and forth, clearly not happy about what she had just heard. The pacing, though, was not entirely mirrored in her face. Her expression was one of deep thought, without a look of confusion or worry. As usual, the governor showed herself to be quite capable of quickly grasping the central issues, as well as the complexities of a problem. Her opening

remark to the DOE official was a good example of her ability to........ *

COMPLETE THE FOLLOWING WORKSHEET.

* This fictitious story is based on facts. All of the descriptions of events prior to 1983 are real.

If you are interested in the details of the early days of the Middle East oil industry, there is an excellent account available, *Power Play*, by Leonard Moseley. It is a thoroughly researched, fascinating, and fast-reading book. Though not overly explicit or sensationalized, there are many references to violence and sexual promiscuity--only where such occurrences lend an understanding to important historical events.

A HISTORY OF TECHNOLOGY

WORKSHEET

When an economy is controlled by the prices which result from balances of *supply* and *demand*, it is said that *market forces* are at work.

When it was mentioned, in this lesson, that the "industrial growth of the 1990's has far outstripped even the impressive growth of the 1960's," and that oil prices are "close to the depressed levels of the 1980's oil glut," what is being presented is the way in which the world economy responds to market forces.

When fuel is cheap because of an overabundance of oil (supply), industry will choose to buy (demand) large quantities. The manufactured goods of industry (supply) will then be more readily available and cheaper, meaning that more people will choose to buy (demand) these products.

When an economic system is left to the control of market forces--to competition between private businesses, and to unregulated purchasing by consumers--we call such a system a "free market."

When governments participate in a free market by doing such things as regulating prices or establishing minimum wages, we can consider these acts as the "fine-tuning" of market forces.

Nationalization of businesses is an act which puts all or most of the control in the hands of government.

An important emphasis of this lesson is to acquaint you with some of the forces which balance and disrupt economic systems.

1) How could an "oil glut" and the resulting industrial growth lead to a crisis?

[There is more room on the next page for your answer.]

2) The largest known reserves of oil are in the Middle East. In southern Mexico (extending into northern Guatemala) there are large, productive oil fields which are part of Mexico's nationalized oil industry. Both of these regions are in some ways politically and/or economically unstable. Why might this be of concern to those of us in the United States, in terms of our own economic stability?

3) What, if any, do you feel is the proper role of the U.S. government in stabilizing the Middle East and our southern neighbors?

4) If the U.S. economy is so dependent on oil, should Alaskans export oil to Japan or other countries if market forces make this the most profitable maneuver? Why or why not?

5) Alaskans are familiar with "boom and bust" economies--economies which grow fast and die fast because they rely on only one or a few industries.

Economic diversification, which could buffer our economy by developing a wide variety of industries, is something which is just beginning to happen in Alaska. Do you feel that this will offset our dependence on our oil industry? Why or why not?

(In the early 1980's the state government in Alaska was the single largest employer in Alaska. Over 90% of the money received by the state government came from the oil industry.)

6) In Alaska we use about twice as much energy per person, on the average, than in the rest of the United States. Because energy was cheap in the early 1980's, we have become extravagant energy users. Can we continue to use energy in this way? Why or why not?

7) The market forces which "create" economic incentives (the forces which make us choose to buy or not to buy) can work against the *long-term* needs of a community. When this happens, governments are frequently called upon to alleviate problems not attended to by private businesses. Governments levy taxes and can then use the money collected (revenues) to aid the economy.

Let's look at an example of how a government can work in this way. In the late 1970's the Alaska State Government set up a residential energy-audit program and several energy conservation loan programs. Many people felt that market forces weren't enough to establish adequate economic incentives for the purchasing and installment of energy-saving technologies--such as insulation. Also, for people who wished to experiment with and/or install renewable energy devices--such as solar greenhouses and windmills--money was made available.

In this way, the government helped to establish the use of new technologies, so that Alaska's long-term economic security could be improved. Future increases in the price of fuels could be devastating if we are not prepared.

Do you feel that governments should participate in the economy as described here? Why or why not?

[There is more room for your answer on the next page.]

8) If short-term economic incentives do not lead to long-term economic security, what can and should be done?

9) According to David K. Willis of *The Christian Science Monitor*, "since 1970, major oil companie have lost most of their control over oil production to governments: Companies hold 17 percent of production [in May of 1983], against 72 percent in 1970."

The U.S. government already influences the oil industry. It is conceivable that restrictions on the Alaskan oil industry could be used in times of national emergencies.

Is this possibility acceptable to you as an Alaskan? Why or why not?

[There is room on the next page for your answer.]

10) What do you feel can be done to prevent government restrictions on Alaska's oil industry, if indeed you feel that government intervention is not desirable?

11) Let's stop for a moment and rethink the causes and results of nationalization.

Dependence on imported resources can lead to a crisis if exporting countries nationalize their own industries. The situation in Iran which is described in this lesson is an example of an exporting country taking control of its own oil resources. This caused concern to Great Britain and the United States--two countries who depended on oil imports.

Crisis can also lead to nationalization. When market forces fail to enhance national security, governments can and do intervene. Such was the case which resulted in the nationalization of the banks in Mexico.

Do you think that the imagined future which is presented in this lesson could come true? Why or why not?

12) An emphasis of appropriate technology on self-reliance is partly for the purpose of preventing problems faced in complex economic systems.

Here is an example of an appropriate technology approach:

> Promote energy-efficiency. Replace the dependence on imported fuels and raw materials with the development of local and renewable resources. As part of an economic diversification strategy, small-scale manufacturing industries would be established, to make the products used by Alaskans. Farming and fisheries would be focused on the production of food for Alaskans, instead of for export.

This simplistic "utopian" view of economic development can rightly be called unrealistic. Current market forces won't allow incentives for this appropriate technology approach to develop.

There are many other problems with this approach. Government participation in the economy would have to increase. Also, it could become difficult to import the products that many of us in Alaska like to have available--such as coffee and cars. It would be very difficult to produce these goods ourselves.

Do you feel that the above appropriate technology approach is at all worthwhile? Why or why not?

13) How could some of the appropriate technology strategies be incorporated into the Alaskan economy--as an *addition*, not as a *replacement* of the current economy? This is a very difficult question to answer. [You might want to consider the various "sectors" of society: individual citizens, private businesses, local governments, state govenrment, federal government, and international organizations.]

14) Briefly put yourself into the shoes of the governor of Alaska--in 1995. What would be your response to the Department of Energy official's opening remark? [optional: If you would like to, create a dialogue between the DOE official and the governor.]

15) The following article appeared about half a year after the first draft of this lesson was written. Read it, but don't spend too much time trying to understand all the details. Then answer the question on the next page. [You might notice that we have returned to the region of the world where the ancient Sumerians developed their early civilization.]

THE CHRISTIAN SCIENCE MONITOR Tuesday, July 26, 1983

Iran responds to threat of Iraqi Exocets with a warning to all Gulf oil states

The writer has previously been on assignment in Iran and writes on the area from his current base in Europe.

By Claude van England
Special to The Christian Science Monitor

Brussels

"The Iraqi-Zionist regime knows that if it causes any trouble to Iranian oil exports, all the countries in the area will be prevented from exporting their oil."

This threat came Sunday evening in a Radio Tehran interview with the Iranian minister of foreign affairs, Ali Akbar Vellayati.

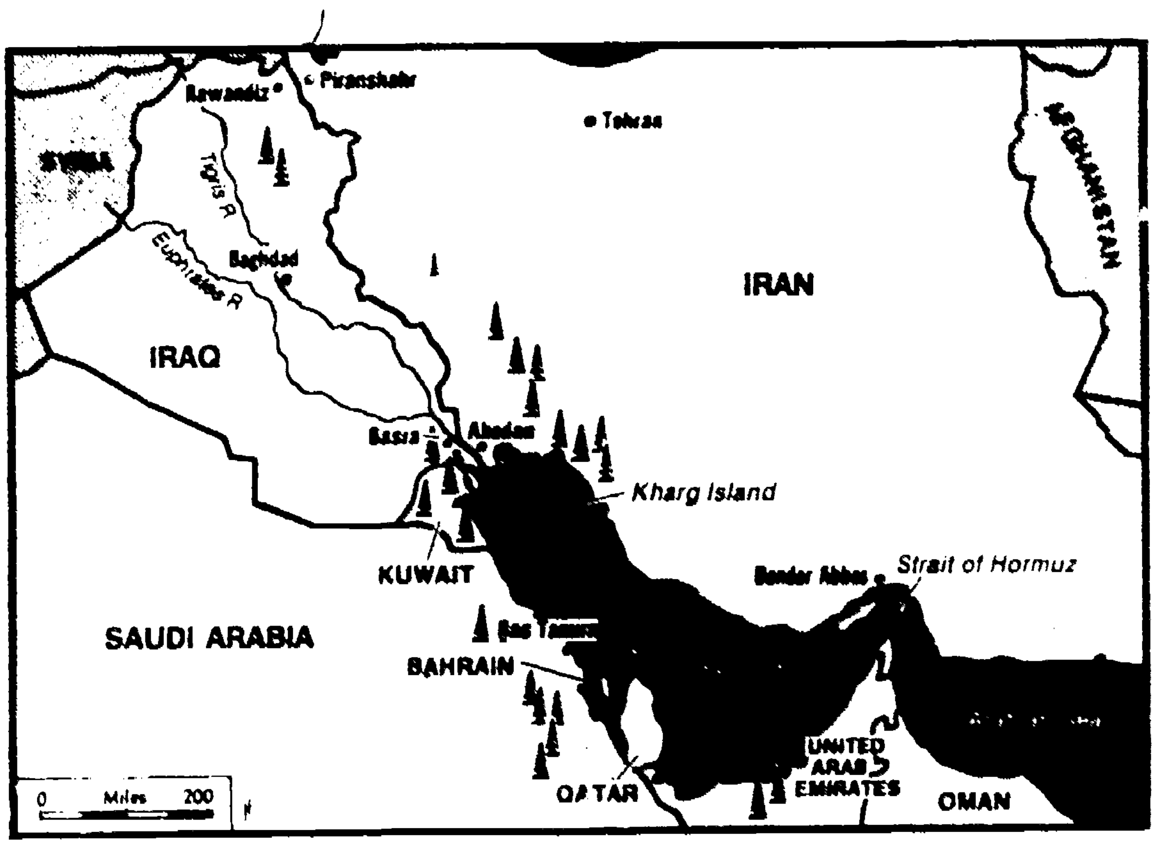
Clearly it means that Iran would respond to a successful strike at its own oil export facilities by either a blockade of the Strait of Hormuz, which commands the access to the oil-rich Gulf, or a bombing of the oil facilities of the Arab states on the south of the Gulf.

Mr. Vellayati is generally seen in Tehran as one of the most moderate leaders of the Islamic regime. He is known for his rather cautious and restrained statements. His warning should thus be taken seriously.

Mr. Vellayati's interview is the first official Iranian answer to the loan by France to Iraq of five Super Etendard aircraft. Super Etendards with Exocet missiles could destroy Iranian oil facilities on Kharg Island. Exocet missiles sank two British vessels during the Falklands war and already have set afire three Iranian oil wells in the Gulf, causing large-scale pollution. The Iranians, who keep the bulk of their Air Force to protect their terminals on Kharg Island, recently confessed there is little they could do against the sophisticated Super Etendards.

The loan of the Super Etendards to Iraq was decided by French Minister of Defense Charles Hernu after Iraqi Prime Minister Tareq Aziz visited Paris in May. Iraqi pilots are to be trained in France.

In recent interviews, Iraqi officials announced they would soon be able to fire



Exocet missiles at Iranian oil facilities.

The jets will remain the property of the French aeronaval forces, and observers say the contract might include clauses limiting their use. The French might have convinced the Iraqis to strike at Kharg Island only in case of an all-out, successful Iranian ground offensive.

Meanwhile, The Iranians are infuriated at the prospect of the arrival on the battlefield of the Super Etendards. The Iranian Navy, which includes destroyers, cruisers, and gunboats, is by far the most important naval force in the Gulf. It is said to have suffered very little from the war and is based at Bandar Abbas, a few miles west of the mouth of the Gulf.

Observers believe Iran could not mount a complete blockade of the Strait of Hormuz, but it could easily attack one or two oil tankers. That would cause a panic and deter other vessels from entering the shipping lane.

Iran could also in the last resort launch air strikes against the oil terminals of the Arab countries bordering the Gulf. One of their targets could be the Saudi oil facilities at Ras Tanura.

But this seems unlikely. The United Arab Emirates (UAE) and Saudi Arabia have substantially boosted their air defense in recent months. The Iranians are also well aware that a strike at their neighbor's oil installations would trigger an international conflict which they are said to be eager to avoid.

Mr. Vellayati's warning comes just as the Iranians are alternating lenient declarations with menacing ones to induce the UAE to withdraw its support for Baghdad.

"You have nothing to fear from the Islamic revolution," said Mr. Vellayati recently. But he added a few days later, "You should refrain from attempting to aid [Iraqi President] Saddam Hussein. Otherwise we'll treat you the same way we treat him."

Observers also see a link between Mr Vellayati's statement and the new offensive launched by Iranian troops within Iraq. Iranian soldiers crossed the border post on the road linking the Iranian town of Piranshahr to the Iraqi town of Rawandiz.

This offensive in the mountainous Kurdish area seems to have been at least partly successful. Iranians say they are 10 miles inside Iraq and they claim they have overrun the Iraqi garrison of Haj Omran.

As usual, Iraqi communiqués give the number of Iranian casualties, but they refrain from mentioning the exact location of the fighting. This might be read as an indication that they are on the defensive.

By 1983, we in the United States had become less dependent on Middle East oil supplies--by developing our own oil resources, such as in Alaska, and by buying oil from other regions. Also, recession and energy conservation slowed down our demand for oil.

But our economy was still much influenced by the international economy. In turn, much of the international economy was still fueled by Middle East oil. Europe and Japan still imported large quantities.

If the Iranians prevented the exporting of oil from the Middle East, how might the United States--and Alaska--be effected? Give this question some serious thought--and then use your wildest imagination to answer it. Don't limit your thinking to a careful answer!

A HISTORY OF TECHNOLOGY

LESSON 5

A contemporary cartoon satirising
Sir Isaac Newton's Laws of Gravitation.

A HISTORY OF TECHNOLOGY

LESSON 5

REBIRTH OF WESTERN CIVILIZATION

To tell us that every [type] of thing is endowed with [a spiritual] quality by which it acts...is to tell us nothing; but to derive two or three general principles of motion...and afterwards to tell us how the properties and actions of all [physical] things follow from those...principles, would be a very great step.

Sir Isaac Newton [1642-1727]
Optics

God keep me...from supposing Up and Down to be the same thing as all experimentalists must suppose.

..........May God us keep
From Single vision & Newton's sleep!

William Blake [1757-1827]
English poet

INTRODUCTION

In this lesson we once again return to the past. We continue with our previous focus on the development of technologies in Europe, as it emerged from the Middle Ages.

During the Middle Ages in Europe, from about 500 A.D. to about 1450 A.D., there was little of the wide-ranging intellectual fervor found in the Alexandrian Museum or in the Moslem universities.

In a previous lesson we mentioned the conquests of Genghis Khan, a Mongol who lived from 1162 A.D. to 1227 A.D. He had swept across the continent on horseback from China to Europe, momentarily bringing the cultures of the Orient and Europe into contact.

THE DRUMS OF KUBLAI KHAN

Shortly after the Mongolian conquest the Italian explorer, Marco Polo, was meeting with Kublai Khan, Genghis Khan's grandson. As barriers between East and West broke down, technologies of China were introduced into Europe.

Printing techniques which made use of movable type and paper probably originated in the Far East. These techniques made it possible for Europeans to print books in large quantities--helping to fuel an explosion of creative activity.

In the next lesson we will discuss some of the consequences of two additional Chinese technologies--the mariner's compass and gunpowder.

REBIRTH OF WESTERN CIVILIZATION

During the Middle Ages, Europe had witnessed little intellectual or technological advancement. The rebirth of Western Civilization which followed this period set the stage for a new era--the era in which you and I live. For it was the thinkers and innovators of the period following the Middle Ages who were responsible for developing many of the features common in the cultures of Europe and the United States today...a culture which is spreading rapidly throughout the world.

[illegible] of the [illegible] century laboriously copying word for word the [illegible] of the [illegible]. This was the only way of multiplying the number of [illegible]

The Printing Press--Knowledge Spreads

Paper was first used in China during the second century B.C. Moslem Arabs learned the process of paper-making from the Chinese around 750 A.D. It is through the Moslems that Europeans learned this skill. By 1200 A.D., paper was being made in Italy.

Printing has its roots in the art of woodcutting and engraving. Techniques which were developed for the making of clocks led to the development of printing with moveable type.

> The 1440's saw the first book printed with moveable die-cast type. The letter-press printing method used by Johann Gutenberg (1399?-1468) was basically the same as the one used for printing woodcuts, but Gutenberg used cast, moveable type instead of cut blocks....It does not detract from Gutenberg's contribution that printing with moveable type had been practiced in the Far East, or more specifically Korea, two thousand years prior to this. Several of the techniques...which developed so quickly during the technical revolution of the Renaissance had had predecessors in other parts of the world. (*A History of the Machine*, page 77)

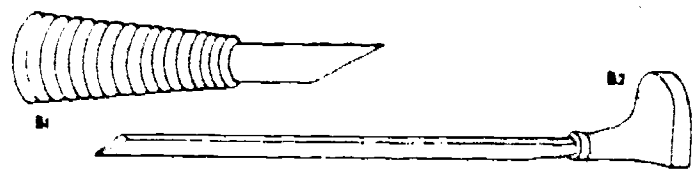
Paper and the printing press gave to the Europeans the ability to easily publish books and other publications in massive quantities. Previously, books had been slowly hand-copied onto treated animal skins.

Historians usually point to the publishing of the Gutenberg Bible in Germany as the first book to be printed in large quantities in Europe.

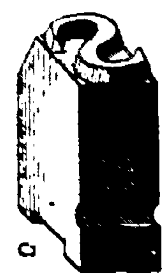
> Only by the fourteenth century did the manufacture [of paper] reach Germany, and not until the end of that century was it abundant and cheap enough for the printing of books to be a practicable business proposition. Thereupon printing followed naturally and necessarily, and the intellectual life of the world entered upon a new and far more vigorous phase. It ceased to be a little trickle from mind to mind; it became a broad flood, in

A

A One of the oldest known woodcuts. It bears the date 1423 and depicts St. Christopher carrying the Infant Christ on his shoulders. The woodcut was found in a manuscript of 1417 in the middle of the eighteenth century.
B Early woodcuts were made using knives of this type (1). The blade consisted of a piece of clock-spring steel. Later, other special tools, such as this graver (2), were used to hollow out those parts of a block which were to remain white during printing.
C The composing room (1) of an eighteenth-century printer's workshop as depicted by Diderot. The typesetter (left) has the copy in front of him. He picks out letters (2) from the typecase and places them in a composing stick (3). The man in the middle of the picture then puts the completed lines in the galley, a long, narrow tray in which typeset text is stored. When the whole copy has been typeset, the page-maker (right) steps in and puts the typeset lines in forms which have the exact width and height of the book's pages. He then sees to it that all types are at the same level by hammering against a flat, wooden board, which is placed over them.



B1 B2



C2

C3

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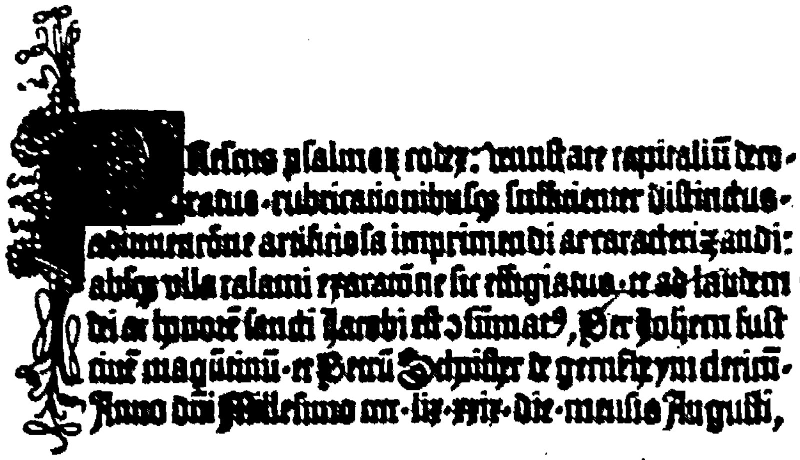
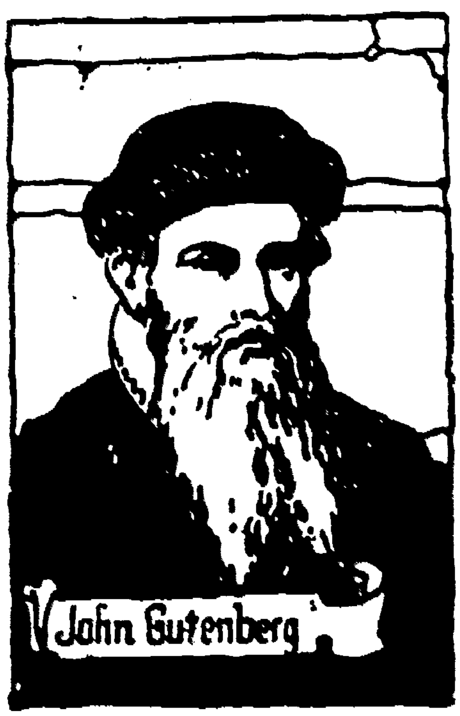


CLOSING LINES OF THE PSALTER OF 1459 (MUCH REDUCED)

The closing lines (that is, the so-called *colophon*) of the second edition of the Psalter, which are here reproduced, are substantially the same as those of the first edition. They may be translated as follows: "The present volume of the Psalms, which is adorned with handsome capitals and is clearly divided by means of rubrics, was produced not by writing with a pen but by an ingenious invention of printed characters; and was completed to the glory of God and the honor of St. James by John Fust, a citizen of Mainz, and Peter Schoifher of Gernsheim, in the year of our Lord 1459, on the 29th of August"

which thousands and presently scores and hundreds of thousands of minds participated. (*The Outlne of History*, page 718)



The publishing of books and the ability to read spread rapidly. Not only was there a great increase in the amount of books printed, but books were written in common languages. In earlier times most books had been written in Latin, the language of the Church. The skills of reading and writing had been a rarity, usually limited to members of the clergy.

By the sixteenth century, books were being written in the languages used in everyday life, such as Italian, English, French, Spanish, and German. This is about the time that Shakespeare was writing in English and Cervantes in Spanish. Shakespeare's plays and Cervante's novel, *Don Quixote*, helped establish important literary styles which remain with us today.

Ancient Greek Thought Arrives in Europe

The technology of printing helped to stimulate a rebirth of interest in science. Arab translations of the early works of the Greeks were translated into European languages. The Europeans built fortresses of new ideas upon the foundations of Greek thought.

> ...Western Europe broke out into a galaxy of names that outshine the utmost scientific reputations of the best age of Greece. Nearly every nation contributed,...for science knows no nationality. (*The Outline of History*, page 732)

Roger Bacon: A New "Look at the World"

To those of us living in 20th century America, it can be somewhat difficult to understand the medieval mind of the thirteenth century. The urging of Roger Bacon during that century, "Cease to be ruled by dogmas and authorities; look at the world," could easily seem of little importance.

Bacon's passionate insistence on the need for experimentation in proving theories, and his collecting of knowledge, were reminiscent of Aristotle, who had urged the Greeks to similar aims. To the people of the Middle Ages, orthodox religious doctrine was often the main source to be consulted whenever there was a need to prove or disprove an idea.

Leonardo da Vinci

Many of the thinkers who followed Bacon did as he urged. One of these was Leonardo da Vinci (1452-1519), who came from Florence, Italy. He was a

naturalist, an anatomist, and an engineer, as well as an inspired artist.

Da Vinci was very prolific, recording his ideas in drawings and notes on more than five thousand sheets of paper. The sketches of his inventions included machine guns, tanks, a submarine, a flying machine, lathes, pumps, water wheels, a canal lock, drawbridges, wheelbarrows, a diver's helmet with air hose, roller bearings. a self-propelled carriage, a double-decked city street, sprocket chains, an automatic printing press, a universal joint, a helicopter and many more ingenious devices.

Many technologies which are common today were first conceptualized by da Vinci.

Galileo Galilei

Another great Florentine scientist and inventor, Galileo Galilei (1564-1642), was born in the same year as Shakespeare. Bronowski claims that Galileo is the originator of the modern scientific method.

Galileo invented one of the first telescopes, which became a commercial success as an instrument of navigation. By increasing its power of magnification and turning it to the stars, he used it as an instrument of scientific research.

Galileo was a practical scientist, having built the apparatus necessary for his work. He carried out his own observations, developed theories, compared his observation to theoretical predictions, and published the results of his work. These steps are the central core of modern scientific method.

Galileo and the Copernican Revolution

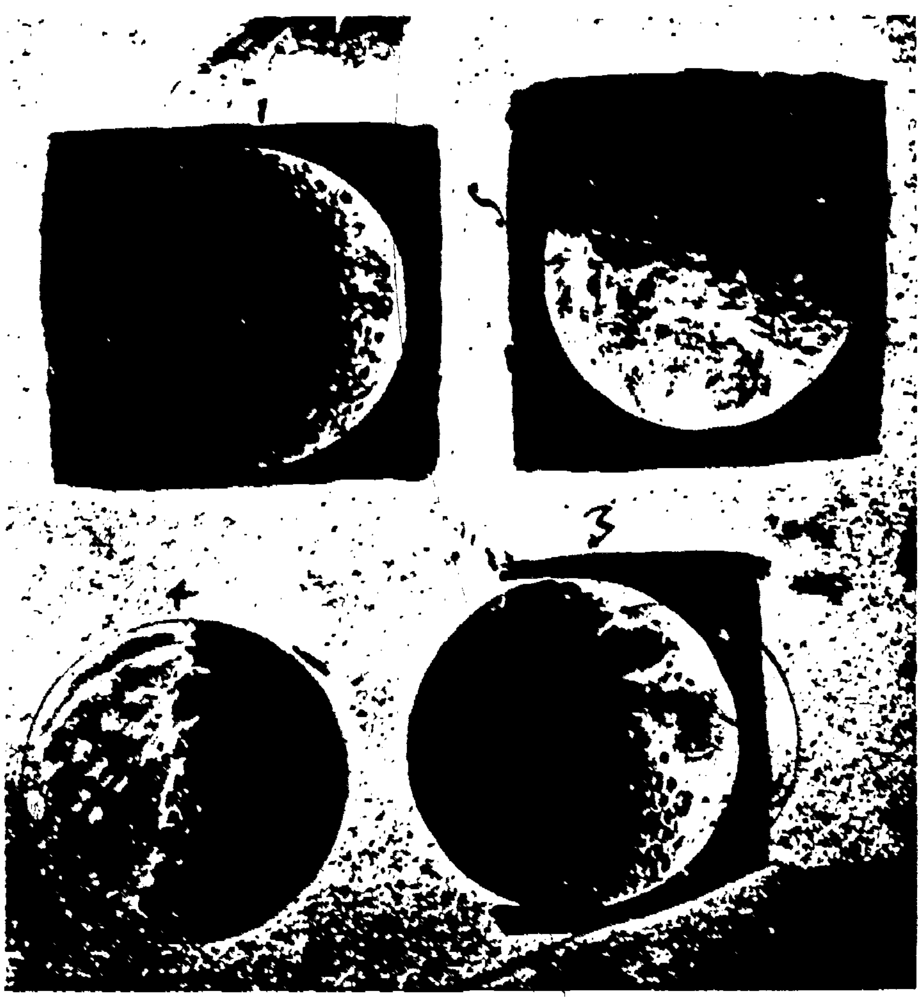
There are few people, if any, able to live without beliefs. Most of us have assumptions about who we are, what is right, and what is wrong. Our interpretations of "what is real," consciously stated or in our subconscious mind, are very important. These interpretations form the basis for our daily actions....and our sense of well-being.

...the human mind, generally speaking, does not just think; it thinks with ideas, most of which it simply accepts and takes over from its surrounding society.....

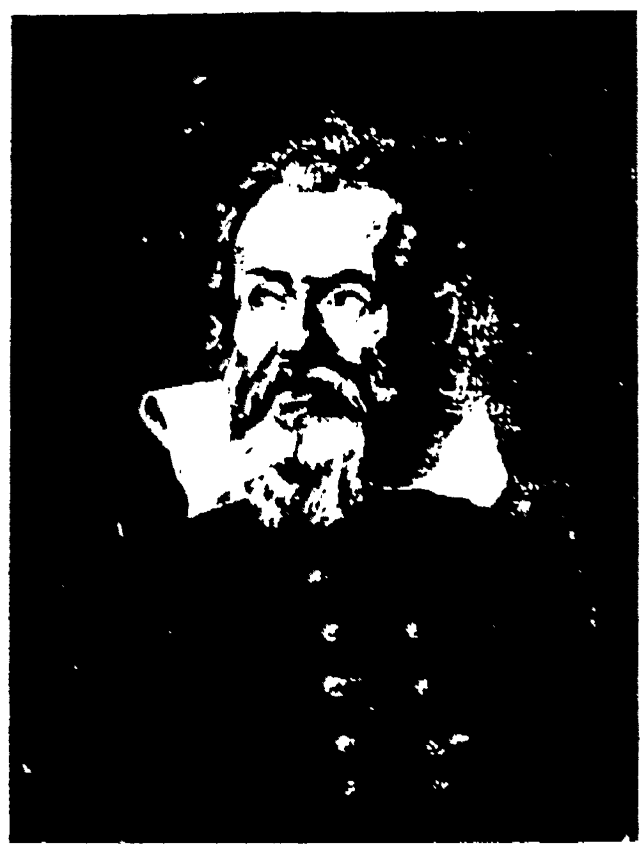
Every thought can be scrutinized directly except the thought by which we scrutinize.

E. F. Schumacher

To many of the inhabitants of medieval Europe, orthodox religious doctrine filled all of the needs for all beliefs. One common belief at that time was that the earth was at the center of the universe. Some of Galileo's findings, which lended support to the theories of a Polish astronomer, Copernicus, indicated that the earth revolved around the sun.



'It is a most beautiful and delightful sight to behold the body of the moon.' *Galileo's own wash drawings of the phases of the moon as seen through one of his telescopes of 1610.*



Galileo's Observations and Beliefs Get Him Into Trouble

Galileo's study of the stars and planets brought him to the conclusion that Aristotle and other ancient Greek scientists had been wrong about the movements of the sun and the earth.

Galileo's support of Copernicus got him into deep trouble with the Pope and cardinals of Rome. The Church, basing its beliefs on the writings of Aristotle, taught that the earth does not move and is the center of the universe. The theological reasoning of the Church was that God is concerned about humans, so He put them in the center of the universe. Galileo's interpretations based on his observations, however, contradicted the beliefs upheld by the Church.

For several years the clergy of the Church tried to persuade Galileo to deny his support of Copernicus' notion that the earth circled around the sun. Finally they put him on trial. At the age of seventy, under the threat of torture, Galileo denied his beliefs. He was confined to his home for the rest of his life and was forbidden to publish any of his writings ever again.

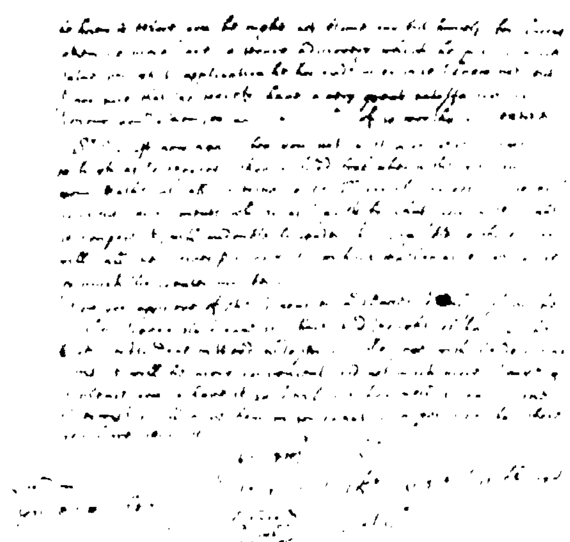
> The effect of the trial and of the imprisonment was to put a stop to the scientific tradition in the Mediterranean. From now on the Scientific Revolution moved to Northern Europe. Galileo died, still a prisoner in his house, in 1642. On Christmas day of the same year, in England, Isaac Newton was born. (*The Ascent of Man*, page 218)

Beliefs are powerful and are rarely given up without discomfort. Maybe the antagonists of Galileo should not be overly criticized. Perhaps we can learn from their short-sightedness so that we do not fall prey, ourselves, to rigid ideas...and to realize the importance of

respecting the beliefs of people who do not share our own particular views.

I do not know what I may appear to the world: but to myself I seem to have been only like a boy, playing on the seashore, and diverting myself, in now and then finding a smoother pebble or a prettier shell than ordinary, while the great ocean of truth lay all undiscovered before me.

Sir Isaac Newton
(shortly before his death)



The Newtonian Universe: A Modern Dogma

Within every culture there is usually a set of beliefs shared by most members. For the culture of modern Western Civilization, Sir Isaac Newton helped to set the stage for a new way of viewing reality. His very exact formulas which describe physical motion, and the mathematical tools which he developed are a cornerstone of modern science....and of many cultural beliefs.

For two hundred years, Newton's mathematical description of the physical universe went almost unquestioned. It was not until the 20th century, with the work of Albert Einstein, Max Plank, and others, that Newton's work has been shown to be an incomplete description of reality.

Two hundred years is a long time for any theory to remain intact. The influence of the Newtonian world-view on our thinking is difficult to understand, because it has become so much a part of modern culture and our assumptions about reality.

Our deepest beliefs can determine what we *notice* in the world around us,

what we *understand*, and how we *act*. This, in turn, affects what technologies we develop and choose to use.

Powerful Tools for Science and Engineering

Even though Newton's ideas have been shown to be incomplete descriptions of how the universe works, they serve well to describe most of the physical relationships which surround us.

Newton's "laws of physics" have been very useful in the advancement of science and technological development. His laws describe the forces of action and reaction which propel automobiles and rockets. His law of gravitation describes the motion of falling rocks and of the planets. His formulas which relate mass and velocity to force are still practical tools used for much of modern science and engineering, as are his mathematical methods.

Humanity Conquers Nature

The apparent accuracy and simplicity of Newton's interpretation of the physical world brought with it a liberating sense of understanding and a newfound ability to *manipulate Nature*. Many people who had felt at the mercy of an unseen spirit-world grew to believe that the world was like one big machine. Simple physical laws could explain all happenings. This often referred to as the ***philosophy of materialism***.

The centuries following Newton's lifetime saw the rise of philosophies based on materialism. Much of modern biology, medicine, sociology, economics, and many other disciplines, rest on a materialist foundation....meaning that events are believed to be caused by "natural physical laws" and are mathematically predictable.

The Newtonian world-view provided practical tools for scientists and engineers. By also helping to weaken the grip of humanity's fear of a spirit-world, and giving to people the belief that they could determine their own fate, a new force spread throughout the world. A rapid expansion of technological innovation followed. The Church eventually lost much of its political and economic powers.

Albert Einstein's theories established new concepts of the [illegible] the harnessing of atomic energy [illegible] German, early in his brilliant career [illegible] position by the Nazis [illegible] 1933 [illegible] the United States and [illegible]

E. F. Schumacher and Materialism

As you learned in the first lesson of this course, E. F. Schumacher viewed technological development in the light of the spiritual needs of humanity.

Schumacher, who was a repected economist, mistrusted many modern economic theories and policies.

E. F. Schumacher expressed the following concerns:

> In the excitement over the unfolding of his scientific and technical powers, modern man has built a system of production that ravishes nature and a type of society that mutilates man. If only there were more and more wealth, everything else, it is thought, would fall into place. Money is considered to be all-powerful; if it could not actually buy non-material values, such as justice, harmony, beauty or even health, it could circumvent the need for them or compensate for their loss. The development of production and the acquisition of wealth have thus become the highest goals of the modern world in relation to which all other goals, no matter how much lip-service may still be paid them, have come to take second place....
>
> This is the philosophy of materialism, and it is this philosophy--or metaphysic--which is now being challenged by events. There has never been a time, in any society in any part of the world, without its sages and teachers to challenge materialism and plead for a different order of priorities.[4] The languages have differed, the symbols have varied, yet the message has always been the same: "Seek ye *first* the kingdom of God, and all these things [the material things which you also need] shall be *added* unto you." They shall be added, we are told, here on earth where we need them, not simply in an after-life beyond our imagination. Today, however, this message reaches us not solely from the sages and saints but from the actual course of physical

events. It speaks to us in the language of terrorism, genocide, breakdown, pollution, exhaustion....

We shrink back from the truth if we believe that the destructive forces of the modern world can be "brought under control" simply by mobilising more resources--of wealth, education, and research--to fight pollution, to preserve wildlife, to discover new sources of energy, and to arrive at more effective agreements on peaceful coexistence. Needless to say, wealth, education, research, and many other things are needed for any civilization, but what is more needed today is a revision of the ends which these means are meant to serve. And this implies, above all

E.F. Schumacher with President Jimmy Carter in the Oval Office of the White House, May 1977.

else, the development of a life-style which accords to material things their proper, legitimate place, which is secondary and not primary. (*Small is Beautiful*, pages 294-295)

COMPLETE THE FOLLOWING WORKSHEET.

If you found the history presented in this lesson interesting, you might want to view a video tape of *Connections #3--Death in the Morning*, available from the Media Services of the University of Alaska, Fairbanks. The show is on 3/4 inch video tape--52 minutes.

(recommended by Richard Seifert, Cooperative Extension Service, University of Alaska)

A HISTORY OF TECHNOLOGY

WORKSHEET

If you feel that any of the following questions are an invasion of your privacy, please do not answer them. Feel free at any time to let your teacher know if you prefer not to complete an assignment because of your beliefs.

1) Briefly summarize the effects that the introduction of paper and printing had on Europe.

2) Do you believe that it is good, bad, or neither, for new ideas to be discussed? Why or why not?

3) It seems that technologies can influence the beliefs of a culture, and that the beliefs of a culture can influence technology. Do you think that this is so? Why or why not?

4) Bacon, Galileo, and Newton sought learning from an examination of the world around them. This approach to learning is often called "science." Do *you* think that the methods of science, based on proving or disproving theories by observation and experimentation, are in conflict with other ways of learning? Explain your answer.

5) Briefly describe the "philosophy of materialism."

6) Do you think that materialism has much influence in the world today? Explain.

7) What effects do you think that beliefs have had on the development and uses of technology in today's world?

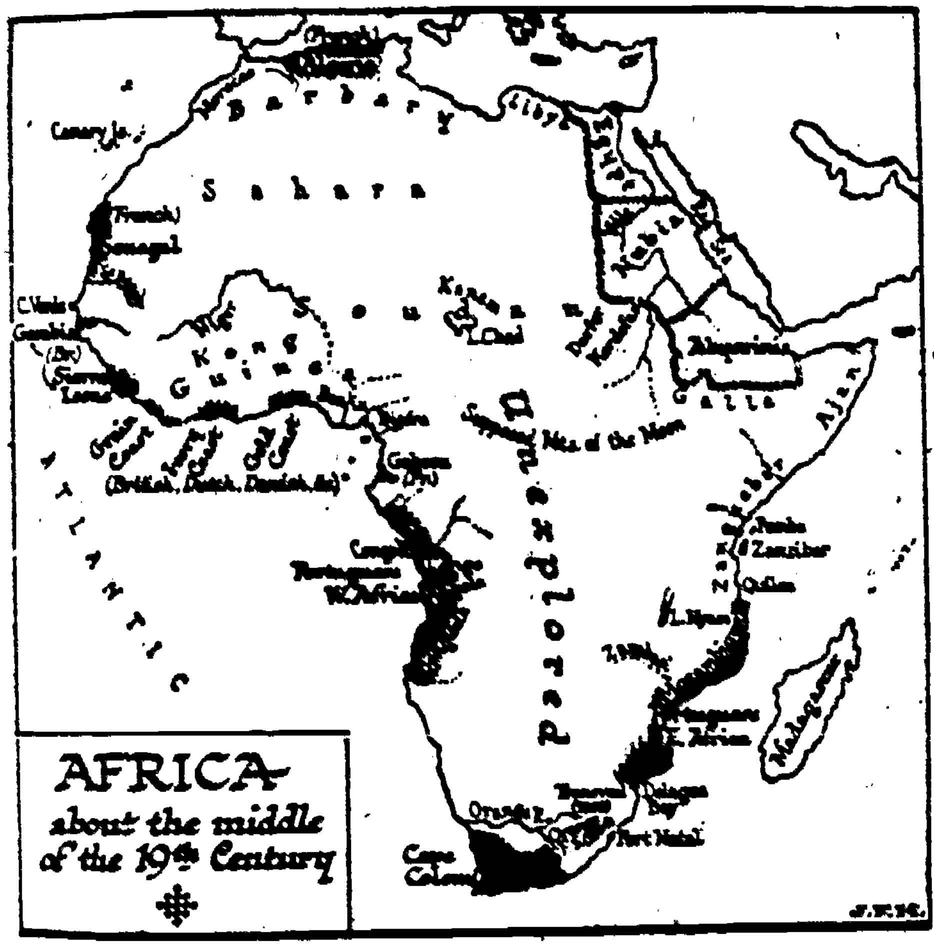
8) If you were the director of research at a university in Alaska, what types of technology would you have the scientists and engineers work on?

9) For the technologies which you listed above, can you pick out some of your own beliefs which you used for making the decisions? If so, what are they?

A HISTORY OF TECHNOLOGY

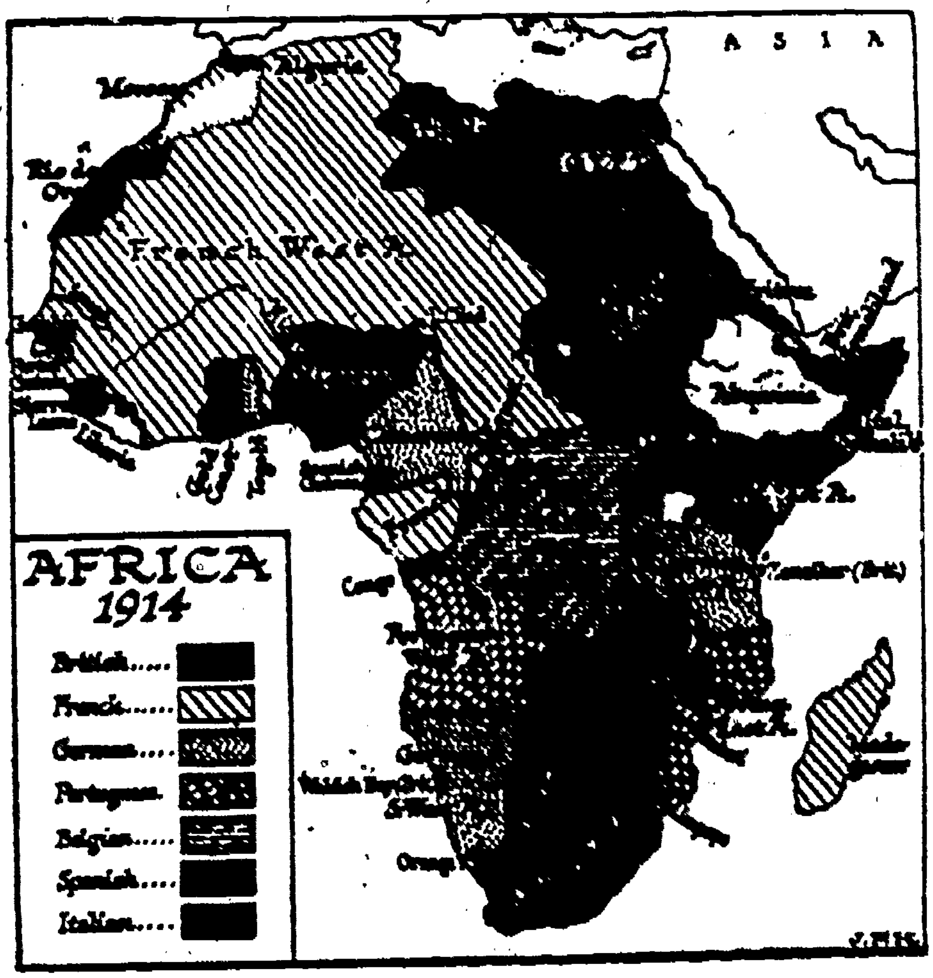
LESSON 6

IMPERIALISM IN AFRICA



The map to the left is a representation of the division of political power in Africa around 1850. As you can see, the continent was largely unexplored, except for the coastal regions.

This map on the right shows the political boundaries of Africa 64 years later, at the beginning of World War I. The only self-governing countries are those shown in white. All the rest are colonies of the European powers at that time.



A HISTORY OF TECHNOLOGY

LESSON 6

BIRTH OF NATIONS
EXPLORATION, COLONIZATION AND THE GROWTH OF INDUSTRY AND TRADING

INTRODUCTION

In the last lesson we discussed the rebirth of Western Civilization.

Gunpowder and the magnetic compass, which are believed to have originated in China, played important roles in changing European society.

In this lesson we discuss the formation of European nations, exploration of the world, colonization, and the growth of industry and trading. We then make some comparisons between early colonies of the European empires and current-day Alaska.

NATIONS ARE BORN AND THE WORLD EXPLORED

During the Middle Ages, political power was not as centralized as it is today. Most of medieval Europe was composed of small feudal kingdoms. Trading between kingdoms was limited and contact with cultures of other regions was rare.

Birth of Nations: Europeans Take Gunpowder Seriously

Gunpowder came to Europe from China during the thirteenth century. It

played a significant role in helping to concentrate the political power of a few kings into what we now call "nations" or the modern political state.

The might of cannons helped these kings to defeat their closest competition--the knights and barons--in the race for power. As political power became more centralized, the kings grew wealthier by taxing the people under their control. The new wealth was used to build better and more weapons, stronger fortifications, and to amass larger armies. This gave the kings the ability to acquire even more territory, money, and power.

Control over new technologies helped to concentrate political and economic power. This concentration of power enabled the kings to give extensive financial support for the further development of technologies.

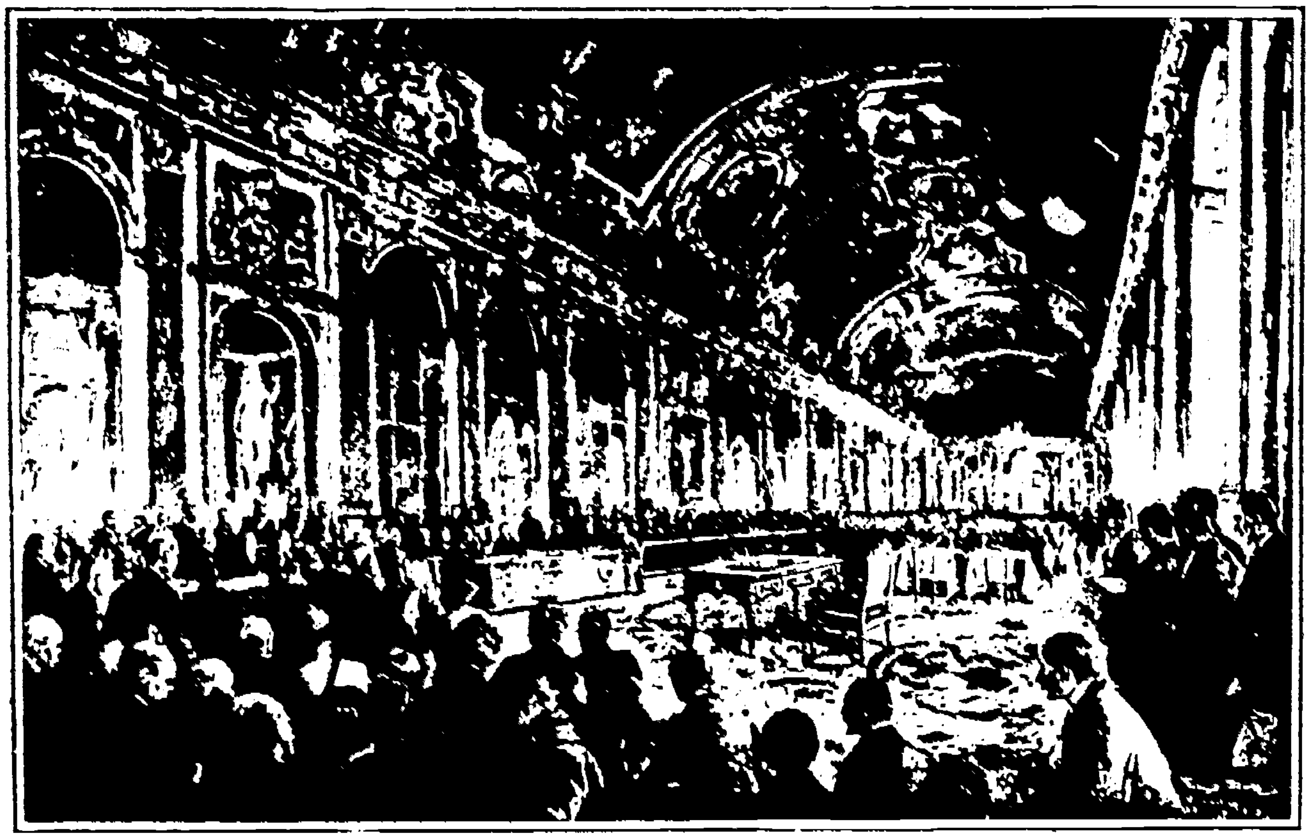
The most famous of all these super-kings was Louis XIV, who ruled France from 1643 to 1715. He set the grand style which earned him the title of "The Sun King," and which was imitated by other monarchs. Louis built the vast, lavish palace of Versailles to entertain and control other French nobles.

> After the time of Mazarin [minister to Louis XIV] we hear of no great French nobles unless they are at court as court servants and officials. They have been tamed--but at a price of throwing the burthen [burden] of taxation upon the voiceless mass of common people. From many taxes both the clergy and the nobility--everyone indeed who bore a title--were exempt. (*The Outline of History*, page 788)

The world of today continues to be influenced by national boundaries and powerful leaders. As a curious coincidence, just as this lesson is being written (June of 1982), many

180

leaders from all over the world, including President Reagan, are gathered at the Palace of Versailles. They have gathered together to discuss world problems. The satellite images coming over the television are of well-dressed leaders, surrounded by the luxuriousness of the palace.



SIGNING OF THE TREATY OF PEACE IN THE HALL OF MIRRORS AT VERSAILLES, JUNE, 1919

Growth of Industry in Europe

The building of the palace at Versailles, in addition to the construction of churches, caused a boom in many industries throughout Europe.

> Every king and princelet in Europe was building his own Versailles as much beyond his means as his subjects and credits would permit. Everywhere the nobility rebuilt or extended their chateaux [castle or large house] to a new pattern. A

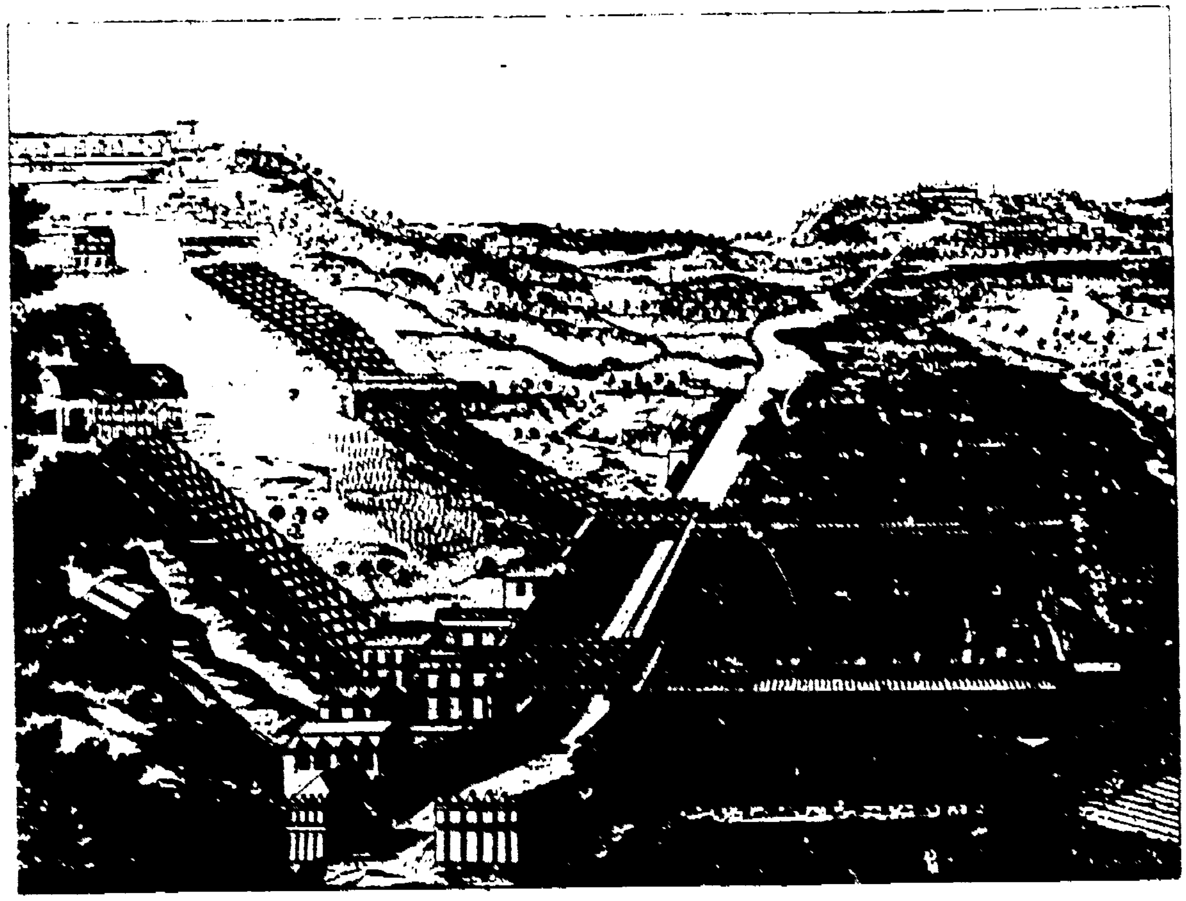
> great industry of beautiful and elaborate fabrics and furnishings developed. The luxurious arts flourished everywhere......Amidst the mirrors and fine furniture went a strange race of "gentlemen" in vast powdered wigs, silks and laces, poised upon high red heels, supported by amazing canes; and still more wonderful "ladies" under towers of powdered hair and wearing vast expansions of silk and satin sustained on wire. Through it all postured Louis, the sun of the world..... (*The Outline of History*, page 788 and 789)

Along with artists and craftsmen, Louis XIV decorated his court with scientists and engineers. The scientific community received money and other resources for research and experimentation, with the largest share of this wealth spent on engineering projects.

One of these projects was the giant Marly machine, which was built to supply water to the palace at Versailles. The Marly machine was a floating water mill, powered by thirteen huge water wheels. This enormous engineering project took 1800 men eight years to complete, at an estimated cost of $20,000,000. Its energy output was 125 horsepower. The English steam engine, which was developed 60 years later, could produce as much power as the Marly machine at a cost of $50,000.

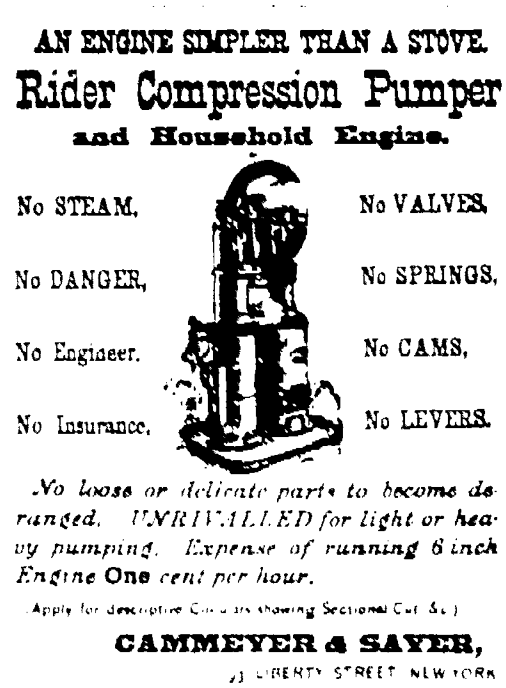
The Magnetic Compass: A Tool for World Exploration

As nations were forming, Europeans began to explore the world. Before the introduction of the magnetic compass, most ships had followed coastlines. Travel across the wide open spaces of the seas was not common.



A

A The giant Marly machine, which was built on the River Seine in the 1680s. Thirteen water-wheels powered 235 force pumps, which pumped up to 1 million gallons (5,000 m^3) of river water into the reservoirs daily. The reservoirs were situated 525 ft (160 m) above the river.

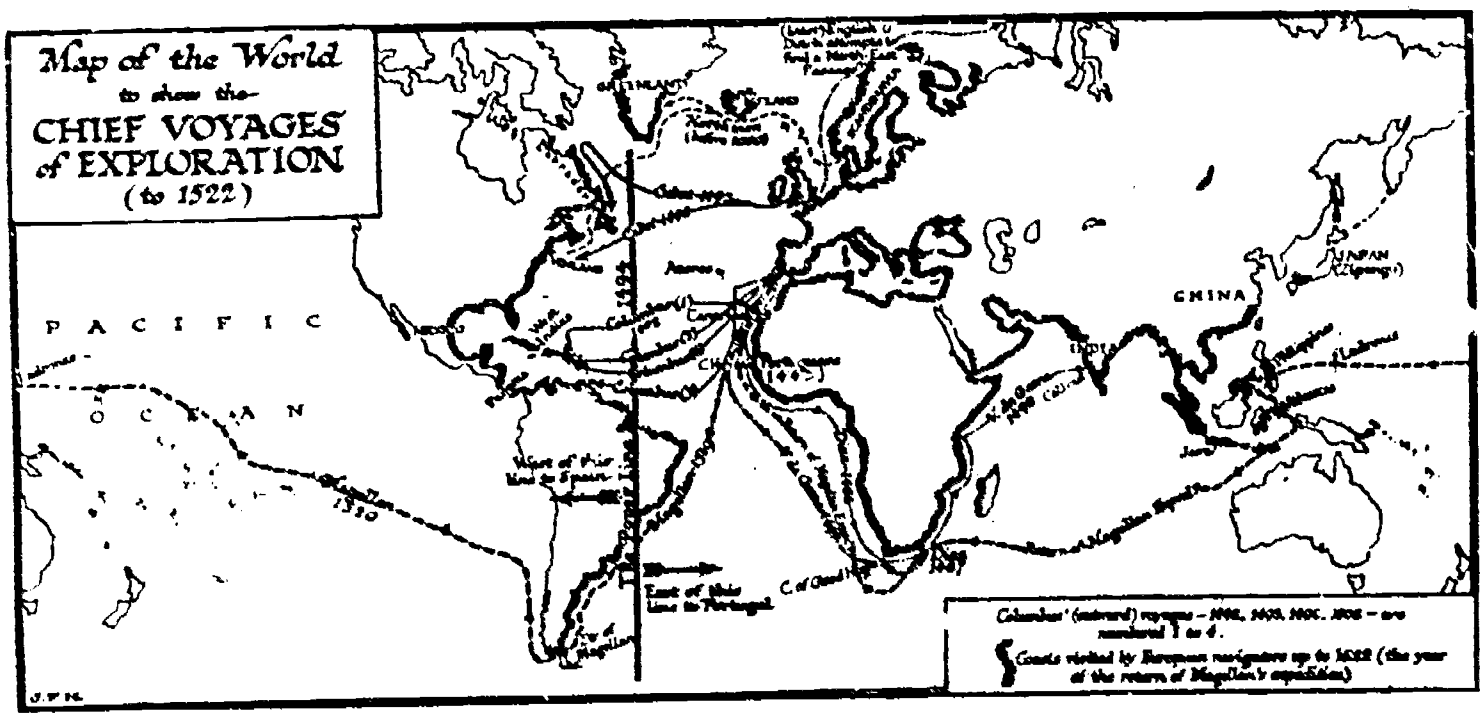


An ad for the Rider closed hot-air engine which produced about one horsepower. It was made in the United States from the 1870's to the 1930's. It was enormously popular because it was easy to run and used any kind of fuel.

Historians are not sure where or when the mariner's compass was invented, but there is strong evidence that it came from China. By the fourteenth century, European sailing ships were crossing the high seas, keeping course by the compass and the stars. In the fifteenth century, adventurous merchants and seamen began to explore the world in search of new routes to the wealth of the Orient, which had been described by Marco Polo.

In the Mediterranean world, the Portuguese were the first to test the new waters. However, the voyage that was to change the world was that of an Italian in the service of Spain--Christopher Columbus. In 1492 Columbus sailed across the Atlantic for what he thought was Japan. He landed in America.

Columbus returned to Spain in 1493. He brought gold, cotton, strange beasts and birds, and two "Indians" to be baptized. It was thought that he had found India, not Japan. He sailed again with a great expedition of seventeen ships, with the permission of the Pope to take possession of new lands for the Spanish crown.



Colonization

The news of Columbus' discoveries caused great excitement throughout Europe. Tales of great riches brought European nations into competition with one another for control of the newly discovered lands. Little consideration was given to the rights of the people already living in America.

Spain dominated the early period of

overseas *imperialism* (the building of empires by the political and economic domination of one nation over another), but France, England, and Holland quickly set their courses for the new wealth in the East and in the Americas. Soon all the major European countries were struggling with each other to establish colonies.

The magnetic compass had helped to open up new riches for European nations. Colonies, such as the one which was to become the United States of America, found themselves firmly controlled by rulers from distant countries.

By the middle of the 20th century, European empires had lost much of their power. Colonies continue to gain the status of independent nations.

The empire which the British created in the nineteenth century was the richest, the most extensive, and the most powerful in history. As master of this vast domain, Britain was a natural target for criticism from other nations. Here the American cartoonist Thomas Nast portrays a swollen John Bull who encompasses the entire world and holds it in a jealous grasp. The envy and resentment incurred by Great Britain in its role as the greatest imperial power of the nineteenth century create political difficulties even today, particularly in those countries where the English were once sovereign.

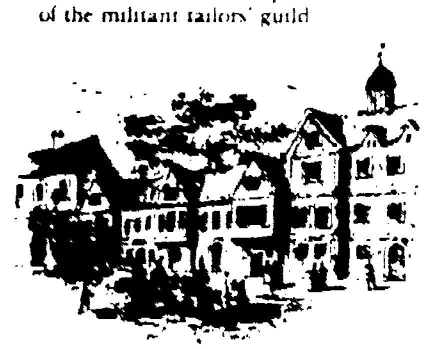
The Guild, an Early Form of Organized Labor

As industry expanded and trading between nations and colonies grew, the structure of political and economic power began to change.

The demand for skilled labor during the European building boom helped to establish and strengthen *guilds*. A guild is an association of people with common interests or skills. Many of them operated much the same as modern business associations and labor unions do today. These guilds were formed to protect its members, and to control wages and training.

One important guild was an association of stoneworkers that called themselves freemasons. By the end of the seventeenth century they began to admit honorary members. Soon, many prominent people were intiated as members.

Tailors' Hall, Threadneedle Street, London, headquarters of the militant tailors' guild



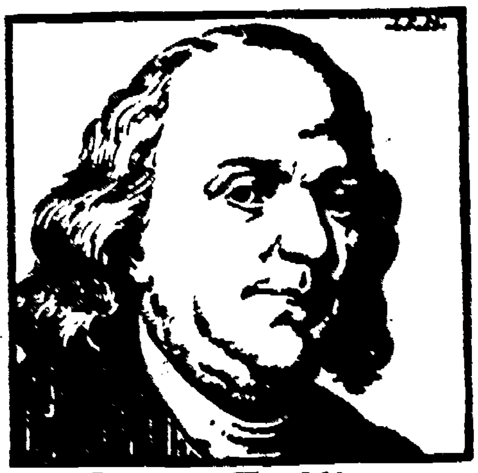
In the United States, Benjamin Franklin, George Washington, and many

other presidents were freemasons. Today, the Masons are one of the largest fraternal organizations in the world.

> The wandering builders were an intellectual aristocracy (like the watchmakers five hundred years later) and could move all over Europe, sure of a job and welcome; they called themselves freemasons as early as the fourteenth century. The skill that they carried in their hands and their heads seemed to others to be as much a mystery as a tradition, a secret fund of knowledge that stood outside the dreary formalism of pulpit learning that the universities taught. (*The Ascent of Man*, page 112)

Private businesses and labor organizations continued to grow in strength during the 19th and 20th centuries.

Ben Franklin: A Revolutionary Kind of Person



Benjamin Franklin

Benjamin Franklin, a Mason, was forceful, forward looking, confident, and very practical. He had little formal schooling--a fact that might have contributed to his originality!

Franklin, a printer by trade, was also a well-known inventor. His inventions have an ingenious simplicity about them, such as the bifocals which he made by sawing the lenses of his eyeglasses in half. He developed a wood-burning stove from cast iron, to increase the energy-efficiency of using wood as a source of heat. His interest in the science of electricity led him to the invention of the lightning rod, which protects houses from lightning.

Benjamin Franklin had a great deal of luck. The fact that he wasn't killed

by lightning during his famous experiment with a kite and a key is one example of his luck. (There is some question about whether or not he really did this experiment at all!) Bronowski mentions another example of Franklin's uncanny luck:

> When he went to present his credentials to the French Court [at Versailles, where Franklin was representing the newly formed United States Govenment] in 1778, it turned out at the last moment that the wig and formal clothes were too small for him. So he boldly went in his own hair, and was instantly hailed as the child of nature from the backwoods. (*The Ascent of Man*, page 268)

Franklin was instrumental in enlisting the aid of the French in defeating the English. The democratic revolutionary government of his country, the United States of America, was to help establish an important trend--the decline of the powerful monarchies and empires centered in Europe.

The independent United States was also to become one of the greatest centers of industrial growth and technological development that the world had ever known.

The steel girders of the George Washington Bridge over the Hudson River act like a giant lightning rod, carrying the electricity into the ground. [illegible] pass safely across the bridge. What would you do to [illegible] yourself from lightning in a thunderstorm?

A New World Order:
Stage Is Set for the Industrial Revolution

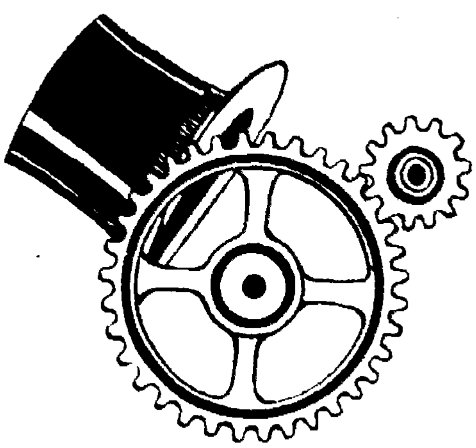
The world which emerged from the Middle Ages was in many ways similar to the world of today. The growing skills of scientists and engineers had led to massive economic expansion, and to a changing attitude.

The formation of strong nations with powerful centralized governments was accompanied by a rapid growth of the European economy. The political power

of the monarchies was giving way to the growth of *privately owned businesses*. Industries and trading flourished. Colonies provided new sources of raw materials and new markets for manufactured products.

The growth of international trade had a significant effect, setting the stage for the emergence of today's industrialized world. In the words of E. K. Hunt:

> Between 1700 and 1770 the foreign markets for English goods grew much faster than did England's domestic markets [markets in England]. During the period 1700-1750, output of domestic industries increased by 7 percent, while that of export industries increased by 76 percent. For the period 1750-1770, the figures are 7 percent [domestic market] and 80 percent [foreign market]. This rapidly increasing foreign demand for English manufactures [manufactured products] was the single most important cause of the most fundamental transformation of human life in history: the Industrial Revolution.
>
> ....profit seeking was the motive that, stimulated by increasing foreign demand, accounted for the virtual explosion of technological innovations that occurred in the late eighteenth and early nineteenth centuries--and radically transformed all England and eventually most of the world. (*Property and Prophets*, pages 41-42)



The next two lessons are about the Industrial Revolution.

Self-Reliance: Alaska of Today Compared to European Colonies

A strong centralized government and extensive international trading had been well-developed by the Romans. For several hundred years after the fall of the Roman Empire, Europeans communities tended to be small and ***self-reliant***, meaning that they provided for themselves, locally, most of what they needed.

A new world order was beginning to develop in Europe and its colonies, one in which people sold their labor for a wage and bought the goods which they needed and wanted. The small self-reliant communities of the Middle Ages were becoming less and less common.

Alaska of today is in some ways similar to the early colonies. Since the end of the last century, many people have come to Alaska in search of gold, other minerals, fish, and oil.

The self-reliant life of Alaskan natives people is in many cases being displaced. The non-native people who live a self-reliant life are becoming a smaller proportion of our population.

Self-reliance is being replaced by a growing dependence on the export of raw materials from Alaska. International trade is becoming a central focus of economic policies.

For many years the Alaskan fishing industry has depended on foreign markets. The building of the oil pipeline from Prudhoe Bay to Valdez has enabled Alaskans to sell oil to the lower 48 states. The export of coal to South Korea from Alaska began in the early 1980's. There is talk of exporting Alaskan barley to the Pacific Rim Countries--the countries lining the coast of the Pacific Ocean, including Japan, South Korea, and China.

Very little manufacturing is done within Alaska, leaving us dependent on outside industries for manufactured products, and most of the food consumed in Alaska is imported. Later in this course we will be examining why this is so.

The future direction of Alaska's economy is in *your* hands.

COMPLETE THE FOLLOWING WORKSHEET

This enormous monarch, his body made up of the tiny figures of his subjects, symbolizes an all powerful government to which the people have surrendered their rights. The illustration appeared in the 1651 edition of Hobbes' *Leviathan*.

A HISTORY OF TECHNOLOGY

WORKSHEET

List three or more of the most important issues presented in this lesson (up to, but not including the section titled: *Self-Reliance: Alaska of Today Compared to European Colonies*). Write a brief paragraph or two about each of these issues.

When you are done writing about these issues, try to see if any of what you have written applies to the situation found in Alaska today. Put your thoughts into a few paragraphs or more. Don't be afraid to reach a conclusion which is quite different than the one presented at the end of this lesson.

A HISTORY OF TECHNOLOGY

LESSON 7


QUICK & SAFE
HUDSON'S SOAP

A HISTORY OF TECHNOLOGY

LESSON 7

THE INDUSTRIAL REVOLUTION

> *We are still in the middle of the Industrial Revolution; we had better be, for we have many things to put right in it.*
>
> **Jacob Bronowski**
> *The Ascent of Man*

INTRODUCTION

The Industrial Revolution began in the countryside of England. Before this revolution, English villagers made products such as pots and pans, woolen and cotton cloth, soap, candles and matches, and a host of other common things which people buy for everyday use. This type of production is called ***cottage industry*** because the people worked in their homes or in small factories.

The products of the cottage industries were carried from villages to cities on barges that cruised the new and expanding English canal system.

Cottage Industries Replaced by Large-Scale Industry

One of the major factors leading to the shift from small-scale cottage industries to large-scale factories was the decline of the Church's control of everyday affairs. During the late Middle Ages, the Church began to lose some of its grip on the European mind.

LONDON IN THE EIGHTEENTH CENTURY

London was almost destroyed by a great fire in 1666. The old city had been a picturesque mass of timbered houses; the new one was built of brick and stone. In the center rose the new St. Paul's Cathedral, whose dome, 370 feet high, is still higher than any other building in the city. Its architect, Sir Christopher Wren, also built most of the churches whose spires are visible here, the eighteenth-century artist having drawn them, indeed, somewhat out of proportion in order to attract attention to them. The column with a gallery around it is "The Monument," erected to commemorate the great fire. At the lower right-hand side is the Tower. Note the houses on London Bridge. The two towers farthest up the river are those of Westminster Abbey, and the roof of the old Parliament buildings can be just made out below them, beside the bridge.

The period following the decline of the Church's influence is often called "The Age of Reason," beginning in the middle of the eighteenth century. The teachings of the Church had condemned luxury and money--for common people at least--which restrained the growth of the business world. As Jacques Ellul, a French sociologist, points out: "That something might be useful or profitable to men did not make it right or just. It had to fit a precise conception of justice before God."

The rebirth of science and the investigation of the natural world began to uncover things which ran counter to religious teachings, such as Galileo's discoveries which you read about in an earlier lesson.

Many people protested against the amassing of enormous wealth and land and other excesses of the Church, which

helped to speed along early Protestant movements.

Private Enterprise: A New Attitude Towards Business

The new age brought with it more freedom. People began to change the way they thought and behaved. One of the changes was in people's attitudes about the business world. There developed a respect for ***free enterprise***.

Free enterprise simply means that the control of raw materials, manufacturing, and trading rests mostly in the hands of private businesses and market forces. Ideally, this means that everyone is entitled to use personal initiative and work to get a fair share of a society's potential wealth. Everyone has, theoretically, an equal opportunity to prosper from his or her own enterprise.

In reality, the "fairness" of free enterprise did not always result in equal opportunity. Some people already had the economic advantage of wealth, property, and social status. Some profited unfairly on the labor of other people.

The winning combination for success in the new business world was money, business and technical skills, and inventiveness. In the early days of the Industrial Revolution, there were no free public schools which provided equal access to the learning of these skills.

In the eighteenth century, industrial workers were gathered into factories by wealthy employers to manufacture products in greater quantities. This change was of fundamental importance in the relationship between a person and their work. Almost from the beginning of civilization, manufacturing and service

industries were generally in the hands of the craftsmen or the master of the craft. Craftsmen had been organized in guilds and most often were self-employed.

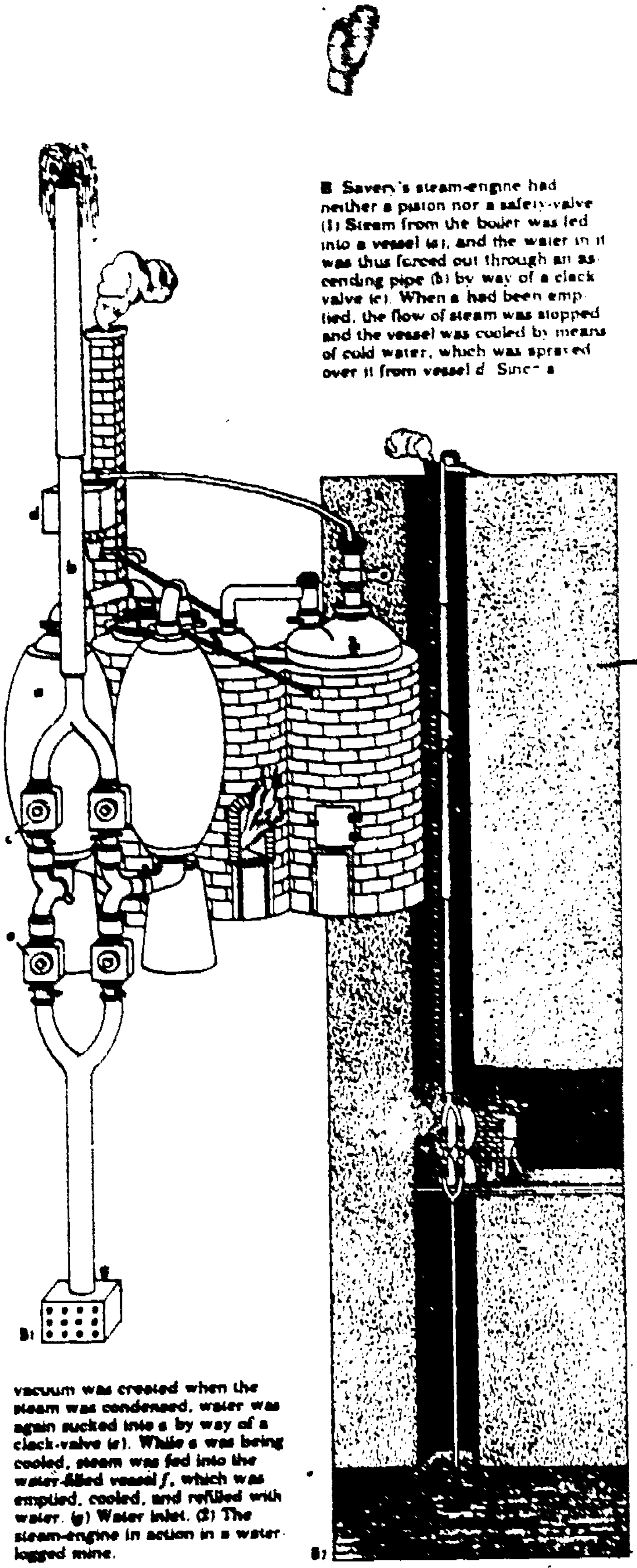
New technological inventions replaced craftspeople. Machines simplified the manual work of factory production. Tasks which before had required a great deal of skill were now being performed much faster by machine.

Scenes of the woollen industry first printed in the [illegible] sheep are sheared of their fleece [illegible] before being spun.

The cotton and woolen industries of England were among the first to pass from the cottage into factory production. In 1764, England imported 4 million pounds of raw cotton. By 1841, this had increased to 500 million pounds, providing raw materials for an expanding textile industry.

Most cotton and woolen cloth had previously been made by simple machines--spinning wheels and hand-operated looms--which villagers operated in their homes. As machines were developed to perform these same tasks more rapidly and cheaply, the village

weavers could no longer compete with the large cloth-producing mills. They had to either seek employment in these mills or to support themselves by other means. Many villagers were forced to move into towns and cities to work in the factories.



B Savery's steam-engine had neither a piston nor a safety-valve (1) Steam from the boiler was led into a vessel (a), and the water in it was thus forced out through an ascending pipe (b) by way of a clack valve (c). When a had been emptied, the flow of steam was stopped and the vessel was cooled by means of cold water, which was sprayed over it from vessel d. Sinc– a vacuum was created when the steam was condensed, water was again sucked into a by way of a clack-valve (e). While a was being cooled, steam was fed into the water-filled vessel f, which was emptied, cooled, and refilled with water. (g) Water inlet. (2) The steam-engine in action in a water-logged mine.

Steam Becomes "The Miner's Friend"

The early factories were at first powered mostly by water wheels. At about this same time, coal was replacing wood as the source of heat for making iron. As mentioned in a previous lesson, the forests of Europe had been depleted by the growth of population and industrial development.

Surface coal was quickly depleted, so miners had to dig deeper to get at underground deposits. As miners dug deeper, their holes filled up with water. Then along came Thomas Savery with the "miner's friend," which was a pump to lift water from the mines. The unique feature of the pump is that it was *powered by steam*.

Savery's pump was the first device to effectively use heat energy as a source of mechanical energy (motion). It was this innovation that was to radically change the already developing factory system of production.

Many historians set the date of 1702 as the start of the Industrial Revolution--the year in which Savery introduced his steam engine.

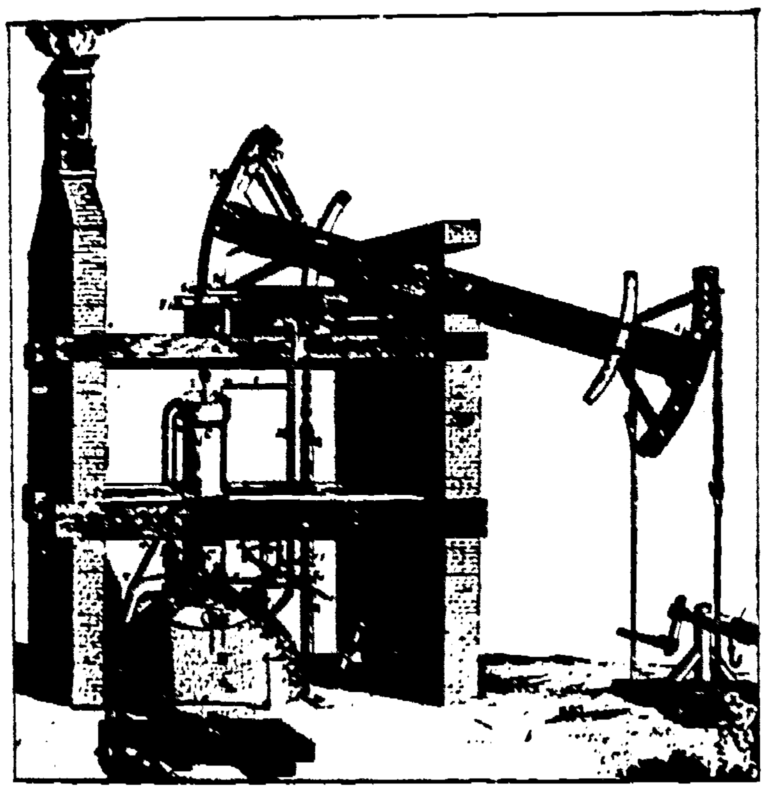
Steam Power Before and After Savery

Thomas Savery was not the discoverer of steam power, nor was he the first to think that it could be used for practical applications.

We have already mentioned that Hero had experimented with steam in Alexandria in 300 B.C. Many other people between the times of Hero and Savery had experimented with steam engines. But none of these had the revolutionary effect of the "miner's friend."

The importance of steam as a source of mechanical energy begins with Savery because the *time was ripe* for the new source of power.

Other inventors and enterprising business people were quick to grasp the importance of steam. Thomas Newcomen, a merchant who traded in mining equipment, and John Calley, a plumber and glazier, invented a steam pump which was a considerable improvement over Savery's device. The new engine was an instant success.



A Newcomen engine (From J. T. Desaguliers, *A Course in Experimental Philosophy*, vol. 2, 1744)

By the time of Newcomen's death in 1729, his engine was in widespread use, pumping water from mines in England and in several other European countries. A Newcomen engine which was installed in a

French coal mine in 1739 operated for forty-eight hours a week with just a few people tending it. Previously, 50 men and 20 horses labored in shifts twenty-four hours a day throughout the week to do the same work.

After seeing the engine perform, the French engineer, Bernard Forest de Belidor remarked:

> It must be avowed that this is the most marvelous of all machines...and that there is not a single other of which the mechanism has so much resemblance to that of animals. Heat is the cause of its motion, a circulation takes place in its different tubes like that of blood in the veins; it has valves that open and close at the proper intervals, it draws from its own work everything that it required for its support. (*Engineering in History*, page 165)

The next major innovation in the development of steam technology was made by another team of two men. One was James Watt, an instrument maker from Scotland. The other was Matthew Boulton, a wealthy English industrialist. As Newcomen and Calley before them, Watt and Boulton combined technical skills with the money and skills of the business world.

Steam Power for Factories

A revolutionizing feature of the Watt engine was that it could drive machinery. Extensive steam-powered factory production opened the doors to a new world.

In 1785 a Watt engine was installed in a cotton mill. By 1800, there were five hundred Watt engines in service. About one third of these were used to pump water. The remaining two thirds

were supplying mechanical power for textile mills, iron furnaces, rolling mills, flour mills, and other industries.

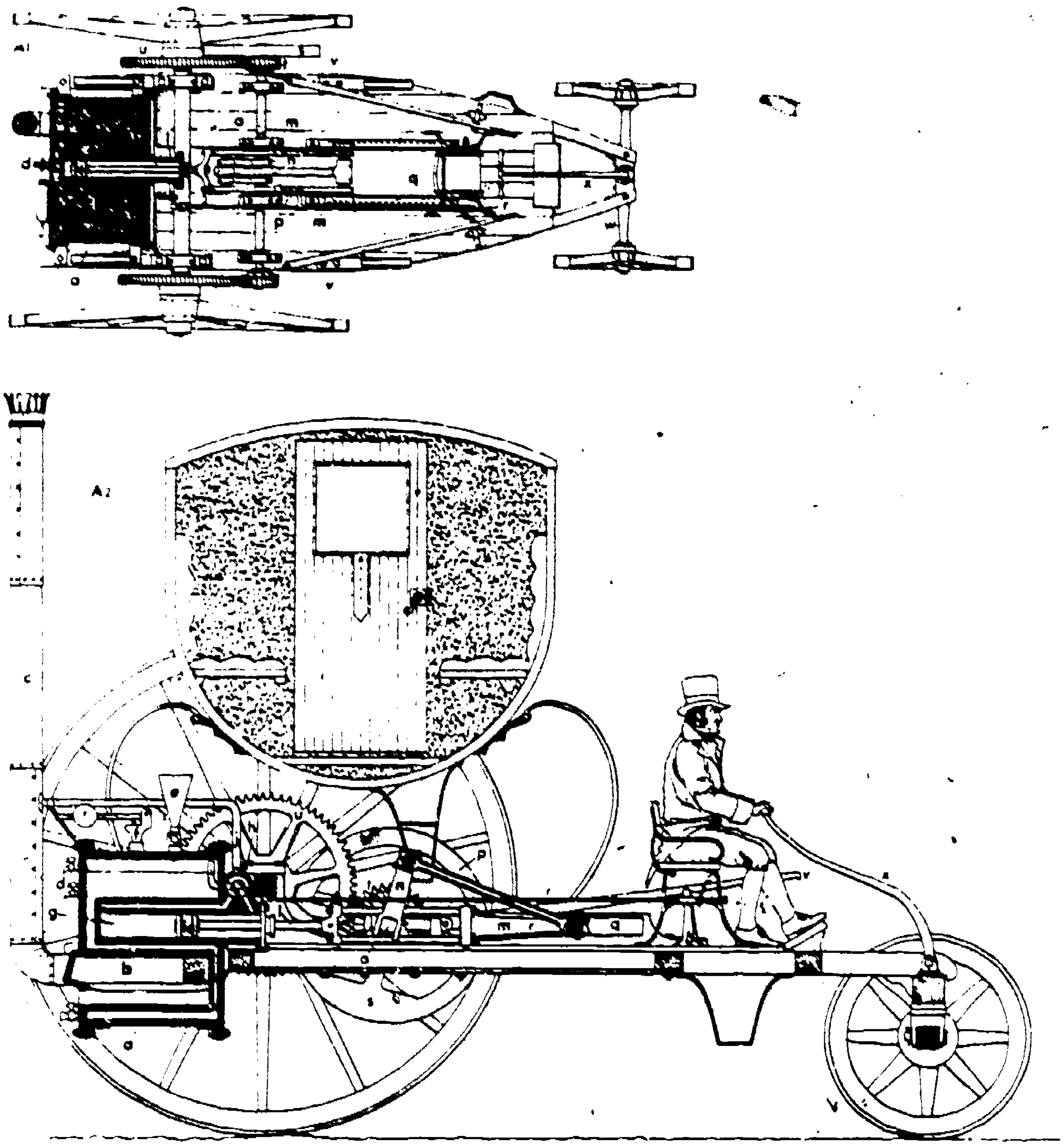
The World Becomes Smaller: Steam Power for Transportation

After the commercial success of Watt's engine, the design of steam engines was steadily improved. This resulted in several new applications of steam technology. In 1804, Richard Trevithick adapted the Watt engine to the first locomotive. In 1825, the first railway began operating, between Stockton and Darlington in England. By the middle of the century a network of railways had spread all over Europe. The speed of transporting people and freight was increased ten-fold. This sudden change is illustrated by Wells:

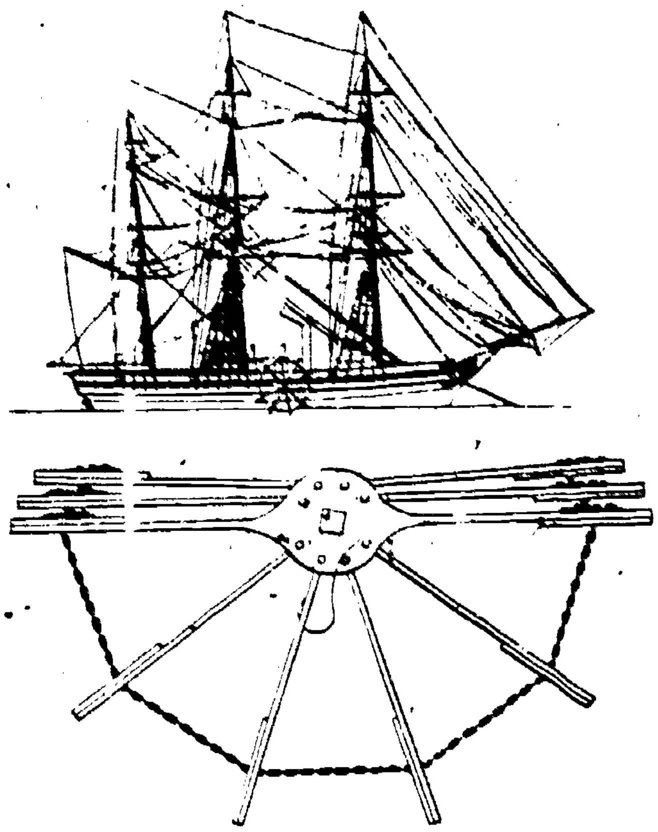
> ...Napoleon travelled from near Vilna [in Russia] to Paris in 312 hours. This was a journey of about 1,400 miles. He was travelling with every conceivable advantage, and he averaged five miles an hour. An ordinary traveller could not have made this same journey in twice the time. These were about the same maximum rates of travel as held good between Rome and Gaul [France] in the first century A.D., or between Sardis and Susna in the fourth century B.C. Then suddenly came a tremendous change. The railways reduced this journey for any ordinary traveller to less than forty-eight hours. (*The Outline of History*, page 924)

The steamboat was developed just a few years before locomotives. By 1802, the paddlewheeler, *Charlotte Dumdas*, was operating on a British canal. In America, Robert Fulton, who had been an art student in England, developed the

A. A reconstruction of Trevithick's steam carriage of 1801 as seen from above (1) and from the side (2). (a) Boiler. (b) Furnace with a double right-angled flue duct. This allowed as much heat as possible from the stack gas to be utilized. (c) Smoke stack. (d) Cocks for control of the water level in a. (e) Water filler funnel with tap. (f) Safety valve. (g) Double-acting cylinder. (h) Steam distributing cock, a 2×2 plug cock. (i) Feed pipe from a. (j) Exhaust steam pipe. Leads to c, where the steam by its blasting action forces the draught. (k) Piston. The piston rod's (l) extension (m) was fork-shaped, in order to give room for the crank web (n), and had vertical openings, to give room for the crankshaft (o). Because of this arrangement, o could be set very close to g. (p) Connecting rod. (q) Guides controlling the fore end of m. (r) An actuating rod, which was connected to h and which, from the driver's seat, could be made to engage with l for an automatic reversal of the distribution of steam to the turning-points of the piston. When disengaged, r could probably be used for manual control of h. (s) Flywheel. (t, u) Gearwheels for the transmission of power to the wheels. (v) Coupling gear, used to disengage either of the wheels when cornering a sharp bend. The front axle (w) was turned round a central pivot by means of the handle bar (x).



first commercially successful steam-powered paddlewheeler. His boat, the *Clermont*, powered by a Watt engine, began sailing on the Hudson River in 1807.



The American steamship Savannah, 1819, and the folding paddle wheel. (From Marestier, "Memoire", 1824).

Like the railroad locomotive, once the steamboat had proved to be reliable and to be a sound commercial investment, it quickly spread throughout the canals and rivers of Europe and America. The first steamship to put to sea was also American, the *Phoenix*, which went from New York to Philadelphia. Another American vessel, the *Savannah*, was the first steam-powered ship to cross the Atlantic Ocean. Wells relates what this meant to ocean travellers:

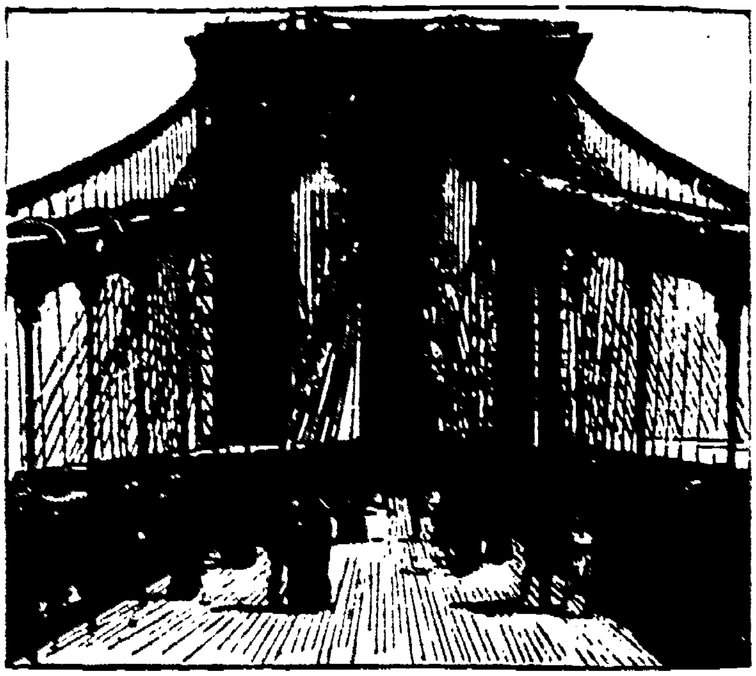
> The transatlantic crossing, which had been an uncertain adventure of several weeks--which might stretch to months--was accelerated, until in 1910 it was brought down to five days, with a practically notifiable hour of arrival. All over the oceans there was the same reduction in the time and the same increase in the certainty of human communications. (*The Outline of History*, page 251)

Iron, Steel, and Electricity: Industrial Technologies Rapidly Improve

Many time-saving, labor-reducing inventions were made during the early days of the Industrial Revolution.

New iron and steel technologies quickly led to even further innovations. The steam engine could not have been developed beyond Savery's primitive pumping engine before the process of rolling sheet iron became available in 1728. By the end of the nineteenth century there were ships of iron and steel, vast bridges, and new technologies for building with steel on a gigantic scale.

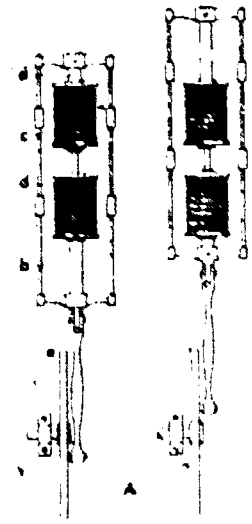
About this same time, electricity was becoming important to the development of technology. The first telegraphs were operating by 1837 in

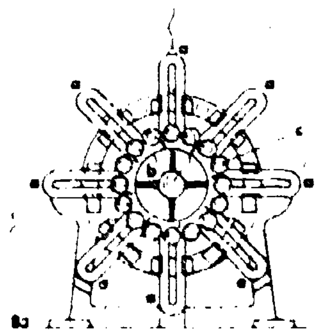


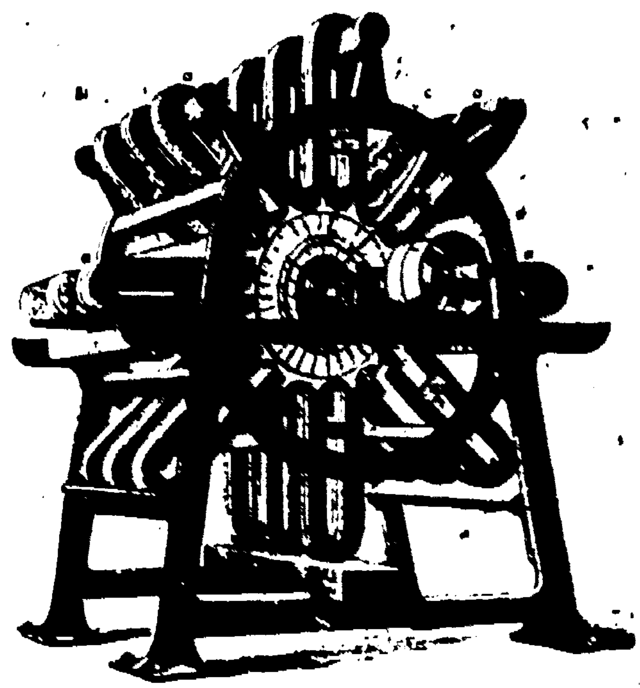
Brooklyn Bridge, original walkway, tower, and cables (From *Scientific American*, 1883)

England and the United States. Soon, great cables were stretched over land and across oceans, connecting the civilized world for the first time with almost instant communication. The telephone, the radio, electic lighting, and many electrically powered devices were soon made available to anyone who had the money to pay for them. Steam-powered electrical generation became common, and continues to be one of the most common forms of electrical power production.

A In the 1830s, several inventors tried to construct electrical engines whose operation corresponded to that of the steam-engine. The American Charles Grafton Page proposed such a "piston" engine, which is shown here at two different stages of its work cycle. Two soft-iron cylinders (a, b) were, in turn, pulled into solenoids (c, d) when these, each during one-half of the fly-wheel's (e) revolution, were fed with electric current.
B The steam-engine-powered Alliance generator (1) was primarily used for lighthouse illumination. (2) Explanatory sketch. The machine consisted of a great number (here, twenty-four) of horseshoe magnets (a), which were arranged regularly in rows round a drum (b). On the drum, twice as many solenoids (c) as magnets were symmetrically mounted. (d) Belt pulley. The machine was large and heavy, and supplied alternating current; because of the many solenoids, it was difficult to make a useful commutator.
C A generator which was considerably less bulky and heavy than the Alliance generator was constructed in 1866 by Henry Wilde. He had discovered the possibility of replacing the large horseshoe magnets with electromagnets (a), which were fed with current from a small generator (b). The latter was equipped with an







Applied Science:
A New Approach to Technological Development

The rapid growth of electrical power can be tied directly to a new method of problem solving. This approach has the *scientist* working with the *engineer* toward a specific goal, such as the development of a new industrial process. This method is called applied science. It was first introduced in the last half of the 19th century and is much different from the way inventions and discoveries had been made earlier.

Earlier technologies had been developed, for the most part, by individuals working on their own, who typically had little or no training in science. In a sense, applied science is the reverse of the way technology had developed in the past. The scientific or theoretical explanation of how early inventions worked usually followed long after the introduction of that invention.

> The best known example [of how technique precedes science] is the steam engine, a pure achievement of experimental genius. The sequence of inventions and improvements of Solomon de Caus, Christian Huygens, Denis Papin, Thomas Savery and so on, rests on practical trial and error. The scientific explanation of the various phenomena was to come much later, after a lapse of two centuries. (*The Technological Society*, page 8)

Governments Fund Technological Advancement

The new field of applied science was helped along by various industries, but in the United States the federal government also became involved in training scientists and engineers. The National Science Foundation was founded and the Morrill Land Grant Act of 1862 was passed by the United States Congress, which gave public land to establish schools.

The railway industry was helped in a similar way by the federal government. Millions of acres of public land were granted to private corporations as an incentive to build railroads throughout the country.

Many, if not most of the technological advances made during our century in the United States, were funded with government money. The

airplane, the submarine, the atomic bomb, and later the nuclear reactor, sonar, radar, the computer and the entire space exploration program were all at least helped along with government funds.

As this lesson is being revised (June 1983) there is a substantial debate going on in the governments of Great Britain and the United States. The focus of these debates is the question of how much these two governments should participate in the development of their industries.

In particular, Japan is seen as a threat, as Japanese industries capture many markets--notably the automobile and electonic markets. The Japanese have a governmental agency, the Ministry of International Trade and Industry (MITI), which helps to coordinate research and development of new technologies and industries.

While the current leaders of the United States and Great Britain (Ronald Reagan and Margaret Thatcher) are very vocal supporters of free enterprise, both of their administrations are realizing that the vitality of their industries are threatened. As we will see later in this course, governmental influence on the direction of science and technology plays an important part in the world of today. In the words of Bonowski: "science is.....a source of power that walks close to government and that the state wants to harness." (*The Ascent of Man*, page 429)

THERE IS NO WORKSHEET FOR YOU TO COMPLETE.

A HISTORY OF TECHNOLOGY

LESSON 8

It was a town of red brick, or of brick that would have been red if the smoke and ashes had allowed it; but as matters stood it was a town of unnatural red and black, like the painted face of a savage. It was a town of machinery and tall chimneys, out of which interminable serpents of smoke trailed themselves for ever and ever, and never got uncoiled. It had a black canal in it, and a river that ran purple with ill-smelling dye, and vast piles of buildings full of windows where there was a rattling and a trembling all day long, and where the piston of the steam engine worked monotonously up and down, like the head of an elephant in a state of melancholy madness. (A description of a typical English factory city about 100 years ago, written by Charles Dickens in his novel "Hard Times".)

A HISTORY OF TECHNOLOGY

LESSON 8

THE INDUSTRIAL REVOLUTION CHANGES SOCIETY

INTRODUCTION

The overall relationships between people is sometimes referred to as the *structure of society*. The development of human technologies has often been accompanied by dramatic changes in this structure.

Witness the growth of cities and of the early empires which followed the establishment of agriculture. Small tribes which depended on hunting and gathering food have been displaced. One exception is Alaska, which is one of the few places where this structure of society still exists, though even here it is no longer common.

The Industrial Revolution began in a world just emerging from a period of centuries in which a feudal structure of society had been dominant. Small kingdoms had been fairly self-reliant and trading between kingdoms had been minimal. Most of the political power rested in the hands of feudal lords. The establishment of nations, which you read about in a previous lesson, consolidated the power of a few royal families.

A nineteenth-century illustration shows the famous Krupp works in Essen, Germany.

The growth of factory-based industry and international trading set the stage for and blossomed with the Industrial Revolution. New forces arose in the world which were to radically

change the structure of society. The forces of *free enterprise* and *massive industrialization* were particularly influential.

A previously decentralized rural society became concentrated into crowded factory-cities. The sharp division between the owners and workers became more of a driving force in society. Labor unions formed to confront the growing needs of workers. A powerful middle class became an important new force. This force was expressed in new democratic forms of government.

A match factory in the East End, from an engraving. In 1888 the girls of Bryant & May's match factory in London, with help from Annie Besant and other Fabians, struck, gained immense public support, and forced the firm to improve wages and conditions; one of the first important strikes by unskilled workers

The fabric of the economy eventually led to the downfall of royalty and the Church as the powers controlling society. In their place arose many new forms of government in which the workers and owners of industry have far greater roles. These changes in the structure of society are still undergoing dynamic changes late in the 20th century, as we continue along the road of a still vibrant Industrial Revolution. With this lesson we arrive closer to the issues facing the world of today.

A NEW WAY OF LIFE: NEW PROBLEMS AND NEW HOPES

Many social problems arose during the Industrial Revolution. The worldwide demand for manufactured goods resulted in the expansion of factories, followed by the rapid growth of towns and cities. Most factories were built cheaply to hold as many workers and machines as possible. The streets were covered in black soot from the smoke of coal fires. Workers' houses were stacked like boxes in some precious cargo space, allowing only enough room to load and unload workers into the narrow streets.

Children not only lived in these tiny houses--they worked long hours in the factories as well. Many of the famous novels written by Charles Dickens, such as *Oliver Twist* and *A Christmas Carol*, described the plight of children in the early factory cities.

This gross mistreatment of humans by other humans did not begin during the Industrial Revolution. What is curious, though, is that the great wealth resulting from the Industrial Revolution did not quickly benefit the multitudes tending the new machines.

In addition to poor working and living conditions for the early factory workers, as Bronowski points out, one more evil was born:

> The new evil that made the factory ghastly was different: it was the domination of men by the pace of the machine. The workers for the first time were driven by an inhuman clockwork: the power first of water and then of steam. It seems insane to us (it is insane) that manufacturers should be intoxicated by the gush of power that spurted from the factory boiler without a stop. A new ethic was preached in which the cardinal sin was not

cruelty or vice, but idleness. Even the Sunday schools warned children that "Satan finds some Mischief still, For idle Hands to do." (*The Ascent of Man*, page 280)

Many of the social problems that accompanied the Industrial Revolution have been lessened in the rich industrialized countries of today. Child labor has been eliminated for the most part in Europe, the United States, and many other regions of the world. Working and living conditions have vastly improved. The work week is shorter and there are many opportunities for education and advancement.

In many countries which are currently in the process of industrializing, especially in Asia, Africa, and Latin America, the conditions of life for workers are harsh.

As will be discussed in later lessons, there is reason to believe that many industries based on large-scale factory production are in the process of substantial changes. Diminishing resources, especially energy, and the automation provided by computers and robots could displace millions of workers. The resulting changes in the structure of society could be dramatic.

People Are Driven from the Food-Producing Land

Before the Industrial Revolution, people in England grew crops and kept livestock on small plots of land near their village cottages. This usually provided them with all the food that they needed and gave the villagers something to fall back on when they could not make or sell the manufactured goods produced in their homes. To a large degree the villages were self-

sufficient. Importantly, many villages were economically independent. The villagers could produce their own food, clothing, tools, and shelter.

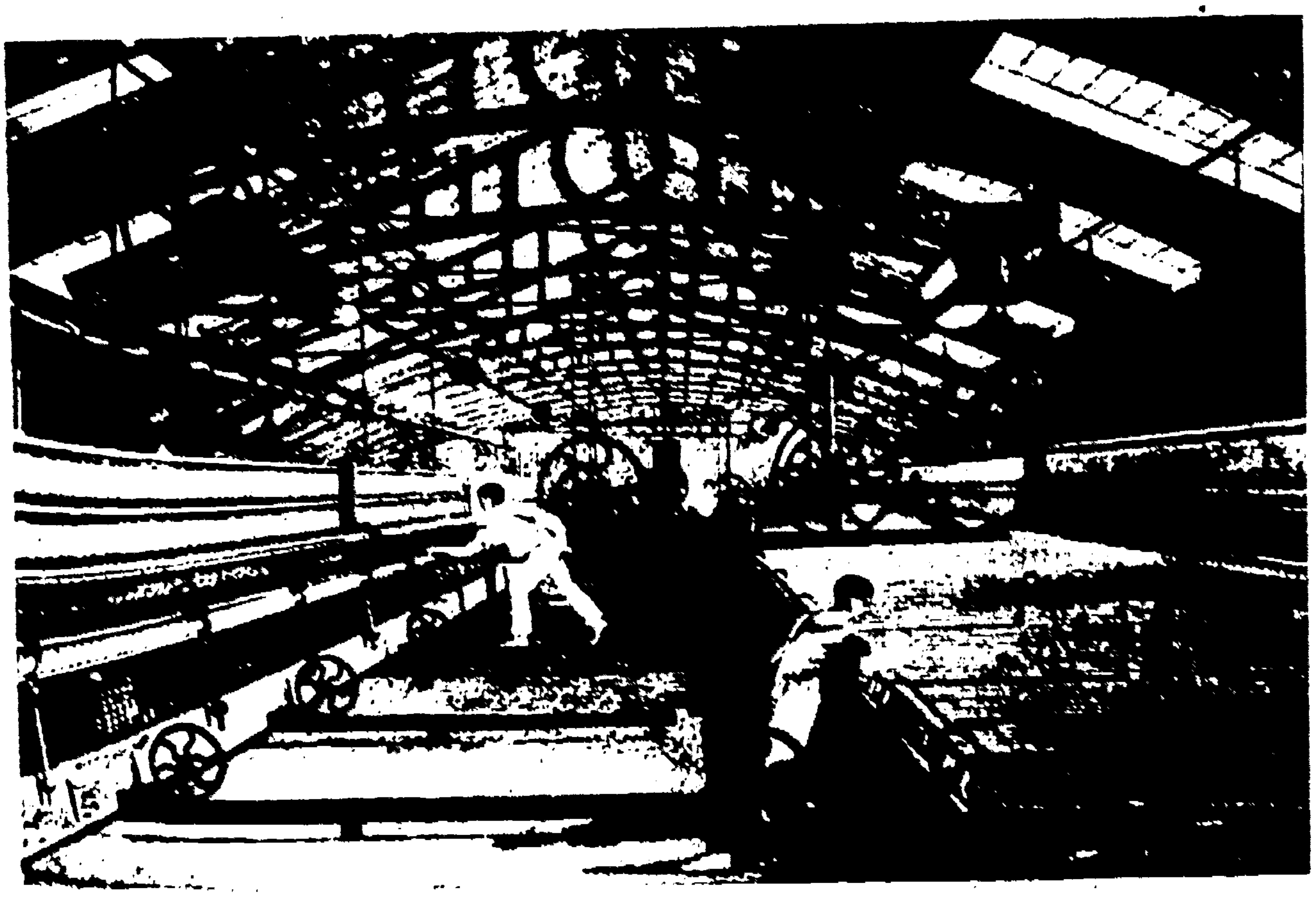
The Industrial Revolution helped to destroy the self-sufficient village life of medieval Europe. Raw materials and human labor were needed for the new factories. The *enclosure movement* helped fill these two necessities of large-scale industrial manufacturing.

> The feudal nobility....fenced off, or enclosed lands that had formerly been used for communal grazing. Enclosed lands were used to graze sheep to satisfy the booming English wool and textile industries' demand for wool. The sheep brought good prices, and a minimal amount of labor was needed to herd them.
>
> The enclosure movement reached its peak in the late fifteenth and sixteenth centuries, when in some areas as many as three-fourths to nine-tenths of the tenants were forced out of the countryside and into the cities to try to support themselves. The enclosures and the

The Great Depression of the 1930's is an example of what can happen in our own times when the factories close and there is nothing to fall back on. Loss of human dignity was one of the most painful tragedies of the depression years in the U.S. Jobless men and women, their hopes crushed by failure and their pride destroyed by hunger, stand and wait in the "Bread Line" - Reginald Marsh

increasing population further destroyed the remaining feudal ties, creating a large new labor force--a labor force without land, without tools or instruments of production, and with only labor power to sell. This migration to the cities meant more labor for the capitalist industries, more men for the armies and navies, more men to colonize new lands, and more potential consumers, or buyers of products. (*Property and Prophets*, E. K. Hunt, page 23)

The destruction of the cottage system of industry took people off the food-producing land and into the cash economy around the factories of the city.



In these cities people had nothing to fall back on during times when factory production slowed down or ceased altogether. There was no welfare system or unemployment insurance as is found in the rich industrialized countries of today. No money meant no food, no

clothing, and no shelter. The choice for people in the cities was brutal if they had no money. They starved and froze to death on the street or they went to debtors' prison if they couldn't pay their bills. Many of these unfortunate people became the first emigrants to the United States and other colonies that were being established by European countries throughout the world.

Meanwhile, agricultural land was being concentrated into the hands of wealthy businessmen. As in the factories, new tools and machines were developed to work the land. Steam-powered reapers and threshers were used along with many new labor-saving inventions. Fewer and fewer people were needed to grow the food and fiber necessary for society.

Population Expands and Cities Grow

The population of the industrial nations of Europe grew rapidly. In 1660 the population of Great Britain was 7 million. By 1820 it had almost tripled to 20 million people, which is the approximate number of people living in New York City today.

A major shift of population to cities is described by Jeremy Rifkin:

> ...As late as the sixteenth century, the majority of European cities housed fewer than 20,000 inhabitants. At the time of the American Revolution, the two largest cities in the colonies--Boston and Philadelphia--had not yet reached 50,000, and New York City ranked a distant third in size.
>
> With the spread of the Industrial Revolution in the early

nineteenth century, all of this began to change overnight. London became the first city with a population of 1 million in 1820. By 1900 there were 11 cities with populations exceeding 1 million; by 1950, 75 cities; by 1976, 191 urban areas composed of 1 million or more people. At present worldwide growth rates there will be 273 cities with populations over a million by 1985...

As a percentage of the world's population, urban dwellers are moving toward a majority. Of the estimated 1 billion people alive in 1800, perhaps 25 million of them--or just 2.5 percent--lived in cities. By 1900, 15 percent of the world's population was located in urban areas. By 1960, one-third of the population. At the current growth rate, by the year 2000 more people will live in cities of 100,000 or more than lived in the entire world in 1960. (*Entropy*, page 150)

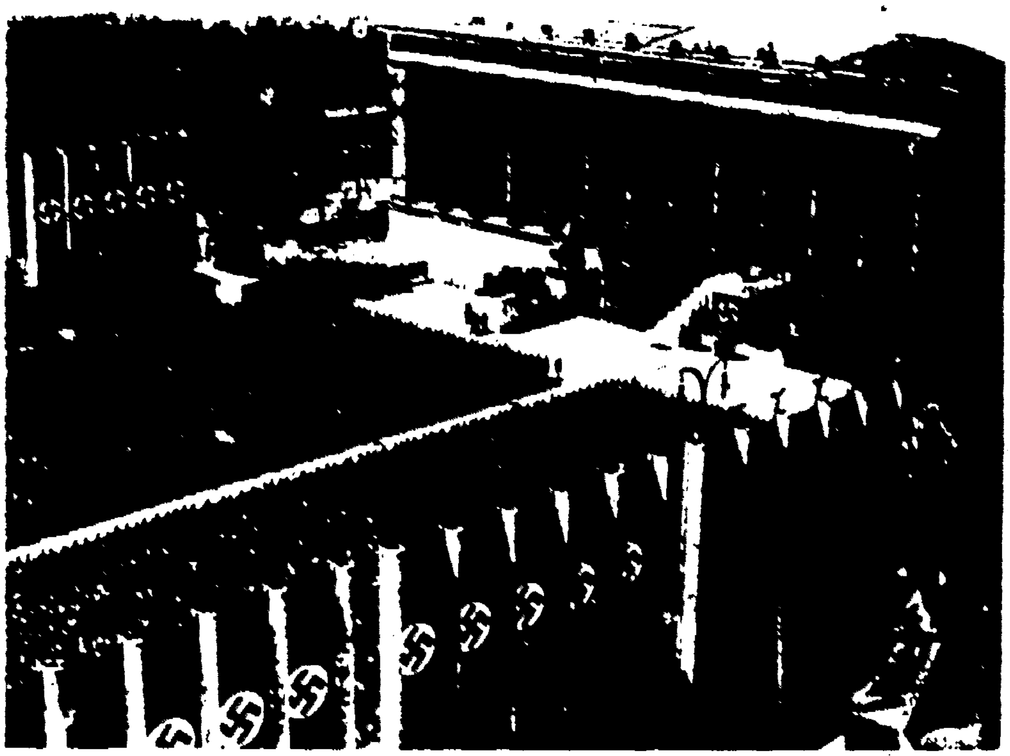
Later in this course we will look at some problems associated with overpopulation. In particular we will consider the depletion of critical natural resources and destruction of natural environments.

Industrialization Paves the Way to a New Social Order

With the Industrial Revolution came new struggles for power. These struggles are a legacy still with us.

Royalty and church clergy have lost much of their power to private businesses and labor unions, and to democratic, socialist, and communist governments. The world of today is in a

state of conflict between groups of people holding differing ***ideologies***-- systems of beliefs as to how economies and people should be (and not be!) controlled. In the news we constantly hear of the debates between "left" and "right" or between "socialism" and "capitalism". Many forms of government and ideologies have arisen in response to the changes in the way people do business with each other.



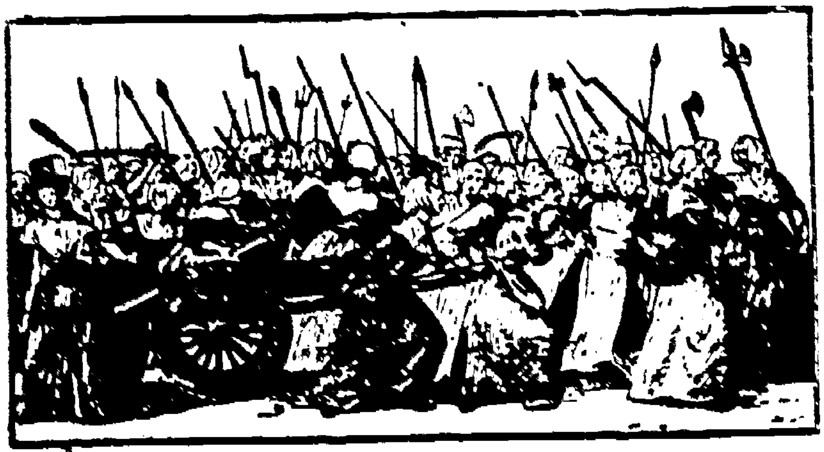
A mass meeting of 50,000 Nazi party members heard Hitler declare on May Day, 1937, that he refused to tolerate any interference by church authorities in German political affairs.

Two important events in the changing social order are presented below: the French Revolution and the American Revolution.

The French and American Revolutions

The French Revolution began when many common people banded together to overthrow the royal government which they felt was taking more than a fair share of the wealth. Much of the rebels' anger was due to the excessive taxation and spending of the aristocracy. You might recall, from a previous lesson, that the palace at Versailles had become a center of great

decadence. While the aristocrats paraded around in all their finery, many of the common people did not have enough to eat.



MARCH OF THE WOMEN TO VERSAILLES

This disregard for the plight of others on the part of the ruling class inflamed the French rebels enough that they beheaded their king and many members of the royal aristocracy.

The French revolutionaries attempted to make radical changes to the structure of French society. Property was taken from wealthy people or heavily taxed. Money and land was divided among the poor people. There was an attempt to abolish profit altogether. In 1793 the rebel government made harsh laws against "profiteering". Major changes were also made in the social system.

The Paris mob launches its successful assault on the Bastille.

> Divorce was made as easy as marriage; the distinction of legitimate and illegitimate children was abolished...A new calendar was devised, with new names for the months, a week of ten days and the like--that has long since been swept away; but also the clumsy coinage (money system) and the tangled weights and measures of old France gave place to the simple and lucid decimal system (the metric system of today) that still endures...There was a proposal from one extremist to abolish God among other institutions altogether, and

to substitute the worship of Reason. There was, indeed, a Feast of Reason in the cathedral of Notre Dame (in Paris), with a pretty actress as the goddess of Reason. But against this Robespierre (one of the leaders of the revolution) set his face; he was no atheist. "Atheism," he said, "is aristocratic. The idea of a Supreme Being who watches over oppressed innocence and punishes triumphant crime is essentially the idea of the people."...So he guillotined Herbert, who had celebrated the Feast of Reason, and all his party. (*The Outline of History*, page 879)

Robespierre and many of those that shared his beliefs met their death at the hands of other rebels.

The American Revolution started more for simple economic reasons than as a result of a dramatically new ideology. There was little social upheaval as compared to the French Revolution. When the dust from the battles settled and the colonies had secured their independence, everyday life went on much as it had before.

THE CONTRAST
A cartoon comparing American and French liberty in 1789.
From C. C. Coffin's "Building the Nation," New York, 1882.

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The Americans had been angered by the way in which they were constantly being forced to pay taxes without having any say on how these taxes were set. Most of the taxed products came from England, even though many of these products were made from raw materials that originated in the colonies (lumber, cotton, and tobacco, to name a few). The British also imposed restrictions which prevented colonies from trading with other countries. In this way Great Britain secured the profits of the new land for the British government or for people they chose.

A RECRUITING POSTER

It reads in part. "The encouragement at this time to enlist, is truly liberal and generous, namely a bounty of twelve dollars, an annual and fully sufficient supply of good and handsome cloathing, a daily allowance of a large and ample ration of provisions, together with sixty dollars a year in Gold and Silver money on account of pay, the whole of which the soldier may lay up for himself and friends, as all articles proper for his subsistance and comfort are provided by law, without any expense to him. . . . Those . . . who shall embrace this opportunity of spending a few happy years in viewing the different parts of this beautiful continent, in the honorable and truly respectable character of a soldier, after which, he may, if he pleases return home to his friends, with his pockets full of money and his head covered with laurels.

From the original in the Pennsylvania Historical Society.

The American and French Revolutions were attempts to set up a new sort of community in the world. Revolutionaries in both nations tried to make a break

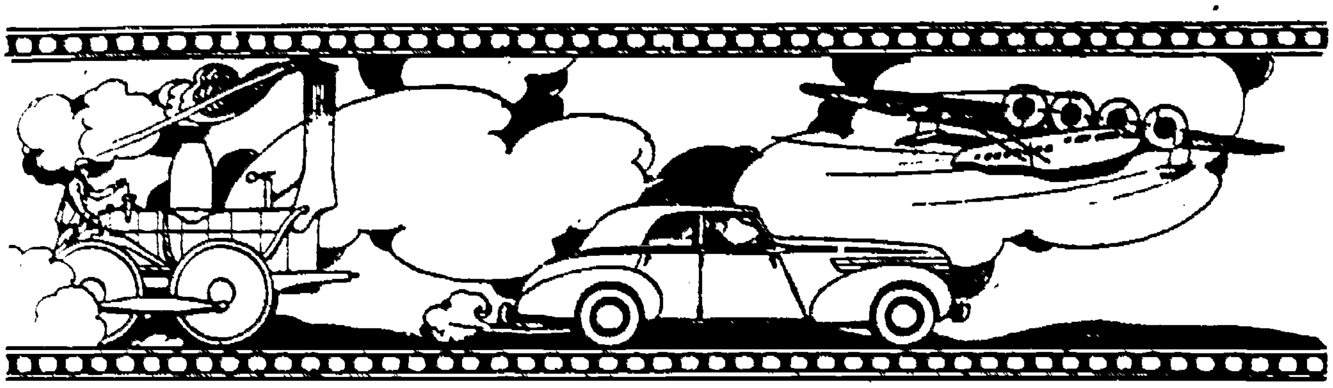
with the past by eliminating the power of the monarchies and by then setting up new laws and constitutions. The French Revolution went much further than the American, by making a clean sweep with the past. Perhaps this is part of the reason that it lasted only a few years.

To this day, debates and armed conflicts continue between organizations holding various ideologies. Though there has been a far-reaching separation of church and state worldwide, groups of people affiliated with various religions continue to play important roles in politics. A current example is the dramatic role of Christian groups in Central America--on both sides of bloody conflicts.

The Industrial Revolution in America

The Industrial Revolution might have begun in England but it was the United States that took the ball and ran with it. Even while the American Revolution was being fought, European ideas and inventions were brought to America and put into practice. Indeed, the pioneering frontier, rich in natural resources and not encumbered by centuries-old traditions, proved to be fertile ground for innovation.

We have already mentioned Ben Franklin's inventions and experiments



with electricity. Another inventor, Samuel Morse, improved the English telegraph, making it a successful commercial enterprise. Another commercial success, as mentioned earlier, was Robert Fulton's steamboat.

The Empire State Building (Courtesy *Engineering News-Record*)

By the end of World War I the United States was leading the world in almost every area of industrial production. Most of the new inventions and discoveries were still arriving from Europe, such as the internal combustion engine and the automobile. Even the atomic bomb was invented by European scientists--though it was on American soil that these scientists were organized to complete this project.

Soon American industry was churning out so many products that homes in this country were busting at the seams with all manner of devices to make life easier and more comfortable. Many of these were found in the kitchen. First appeared the kitchen range, then the sewing machine, the vacuum cleaner, refrigerator, washing machine, electric mixer, coffee percolator, dish washer, can opener, and more.

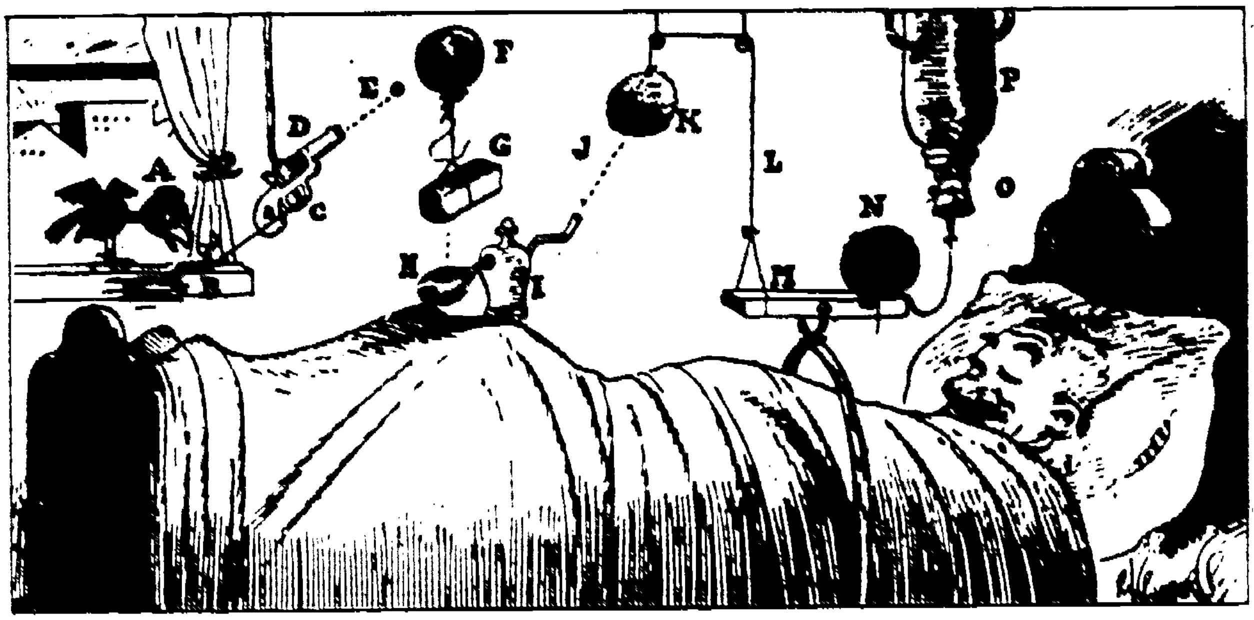
Somehow the automobile won the hearts of the American people. Everyone had to have one and soon "nobody could afford to be without one."

The constant updating of models kept the merchandise moving. People wanted the latest model, or so the new industry of advertising told them.

The enthrallment of the American people with gadgetry and new machines was captured by the American humorist Rube Goldberg.

COMPLETE THE FOLLOWING WORKSHEET.

Simple Alarm Clock



The early bird (**A**) arrives and catches worm (**B**), pulling string (**C**) and shooting off pistol (**D**). Bullet (**E**) busts balloon (**F**), dropping brick (**G**) on bulb (**H**) of atomizer (**I**) and shooting perfume (**J**) on sponge (**K**)—As sponge gains in weight, it lowers itself and pulls string (**L**), raising end of board (**M**)—Cannon ball (**N**) drops on nose of sleeping gentleman—String tied to cannon ball releases cork (**O**) of vacuum bottle (**P**) and ice water falls on sleeper's face to assist the cannon ball in its good work.

LESSON 8

WORKSHEET

It is not unreasonable to be asked questions which have *known* solutions. It can be annoying, though, to be asked questions which are not easily answered. Unfortunately, many of the questions which are important to ask--and to answer--are questions which do not have simple solutions.

Some important and difficult questions are presented on this worksheet, for which there are no simple answers.

The Industrial Revolution and Progress

The *American Heritage Dictionary* defines ***progress*** as:

> 1. Movement toward a goal. 2. Development; unfolding. 3. Steady improvement, as of a society or civilization.

The Industrial Revolution and technological development are often used as examples of progress--as defined by the third definition above. There are also some people who believe that industrialization and technology should be avoided.

Between these two extremes are many attitudes concerning technologies and industries.

Complete the following three statements:

1) In my opinion, the benefits of the Industrial Revolution are

2) In my opinion, the problems associated with the Industrial Revolution are

3) Progress can take many forms. For the progress of humankind I would like to see the following things happen:

Choosing Technologies and the Structure of Society

People develop and use technologies. But *who* decides what kinds of technologies are developed and for what purposes they are used?

Human society exists in many forms, and with each form there is a unique process by which decisions are made. In a dictatorship, most decisions are usually made by one or a few people. In a democracy, there is more liberty for individuals to choose for themselves. In addition to these two general types of governments, there is an almost limitless variety of ways in which people organize themselves for making decisions.

So how do we choose technologies in the United States? It is sometimes said that we leave that decision "to the logic of the marketplace." In other words, businesses and individuals make what people want. The technologies which people are willing to pay for will be produced. Of course, advertising has a great deal of influence on people's desires.

As you have read in this lesson, governments are also involved in the development of technologies. In particular, governments pay for technologies which are used for defense and war, and they also fund the development of technologies which seem to be worthwhile--but for which market forces are not adequate enough to spark the interest of privately-owned industries. You were introduced to this function of government in a previous lesson.

The U.S. government regulates technologies in many other ways. Within the federal government, there are many departments which study and control the uses of technologies, such as the Office of Technology Assessment, the Federal Energy Regulatory Commission, the Environmental Protection Agency, and the Food and Drug Administration.

The government influences technological development by studying technologies, by promoting some technologies, and also by directly regulating technologies.

Answer the following question:

4) In question #3 above, you described the type of "progess" which you would like to see. What types of technologies would be necessary for the progress which you described? By what methods

can our society develop these technologies? How can individuals, governments, businesses, and workers make the necessary decisions to develop the kind of world which you described?

Ideals and Pragmatism

An ***ideal*** is an image of perfection, or an honorable or worthy goal. ***Pragmatism*** is an approach to solving problems which is based on what is actually available. To be pragmatic is to be practical. In some ways, idealism and pragmatism are opposite approaches.

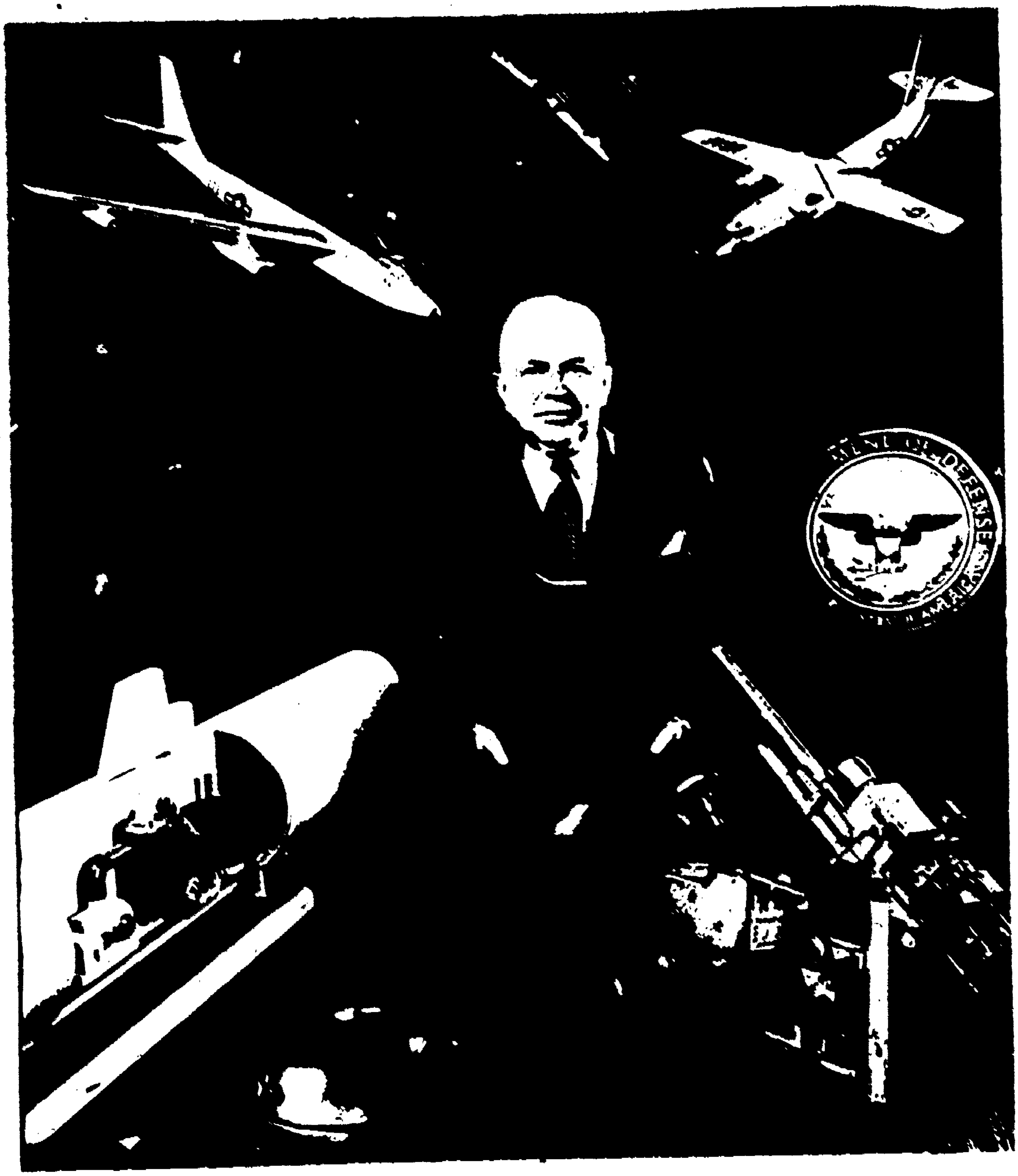
5) Do you believe that idealism and pragmatism can be used *together* for the development of technolgies? Why or why not?

6) Returning to your own description of "progress," what are your ideals, and by what pragmatic means can they be put into practice?

7) What kinds of progress would you like to see, *ideally*, in Alaska? Do you feel that this type of progress is *pragmatically* possible? How could you use the existing structure of Alaskan society to achieve your goals? Would you consider any changes in this structure? [To answer this question, make use of what you know about your local and state governments, and also what you know about organizations such as village councils and local corporations.

A HISTORY OF TECHNOLOGY

LESSON 9



The Pentagon Businessman

As one of President Eisenhower's initial gestures of friendliness to American business, he appointed as his Secretary of Defense Charles E. Wilson, president of General Motors. Nicknamed "Engine Charlie," the new secretary found himself in a political hot seat that required not only executive drive but restraint. Alas, restraint was not Engine Charlie's long suit. He soon embarrassed the Administration by asserting "what was good for our country was good for General Motors, and vice versa." This was quoted by the liberal press in the vice-versa form: "What's good for General Motors is good for the country." He later brushed off critics of a Pentagon expenditure by quipping, "I didn't come down here to run a grocery store."

Such straight-from-the-hip remarks kept coming as Wilson repeatedly spoke his mind. *Chelsea's* Administration critics declared that Wilson suffered from "hoof in mouth disease." Engine Charlie contended, "You have to try to understand what a man means and not what he says." Despite the gaffes, Wilson did a creditable job running his enormous store ($40 billion per year, or 60 per cent of all federal expenses). And when he retired in 1957, the Eisenhower Cabinet lost an able administrator, and surely its most colorful one.

A HISTORY OF TECHNOLOGY

LESSON 9

LOTS OF CHEAP OIL, ECONOMIC BOOM, AND THE MILITARY INDUSTRY

To be prepared for war is the most effectual means of preserving the peace.

George Washington

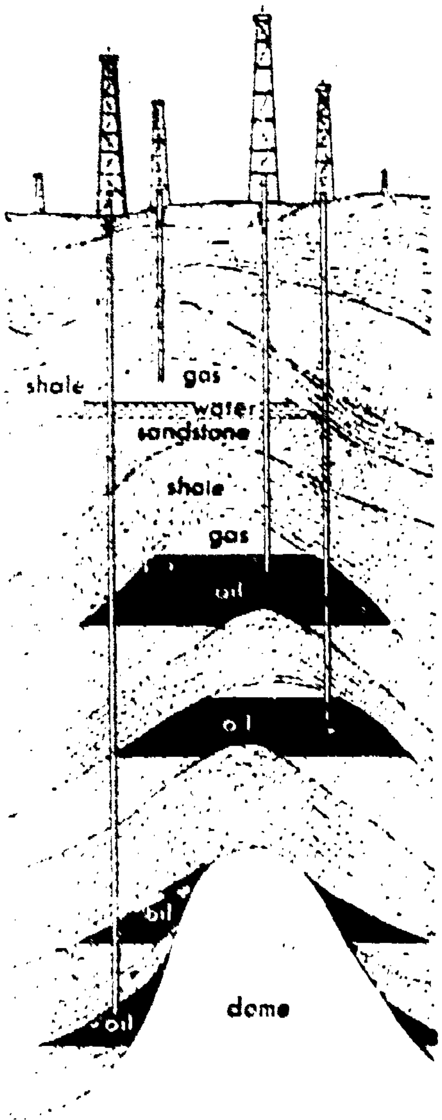
INTRODUCTION

The Industrial Revolution changed human society. With the development of new energy sources, especially oil, came more changes.

Abundant and easily transportable fuels formed the basis for an economic boom that was greater than the world had ever seen. With that boom, also came two world wars and the establishment of mighty military industries--which remain to this day the largest industries in the world.

LOTS OF CHEAP OIL: ECONOMIC GROWTH EXPLODES

Between 1950 and 1973, the yearly production of oil increased from less than four billion barrels to over 20 billion. [A standard barrel of oil is 42 gallons.] This record growth in oil output, and also that of natural gas, fueled an astonishing growth in the world economy.



Rock layers in the earth may become bent and form upward bulges, or domes. If there is water, oil, or gas between the layers, it is trapped in the top of the dome until a pipe is sunk through the rock. The gas or oil may then flow to the surface or be pumped out by machines.

With oil at less than $2.00 a barrel during these years, industry expanded rapidly. The world output of goods and services increased by more than 4% a year.

In the words of Lester Brown:

> Our age is often referred to as the nuclear age, or the space age. Scientifically glamorous though these labels may be, it is petroleum that has shaped our time. The consumption of vast quantities of oil, some 60 million barrels a day at the peak of the oil age during the late seventies, gives contemporary society its distinctive character.
>
> At its peak, oil and its companion fuel, natural gas, accounted for two-thirds of world commercial energy use. Oil was the source of virtually all the world's transportable fuel, much of the fuel for heating buildings and water, and for generating electricity, and together with natural gas, it supplied most of the feedstocks for synthetic chemicals [plastics, fertilizer, and many other synthetics]. (*Worldwatch Paper #53*, page 7)

THE WAR AND DEFENSE INDUSTRIES

Common sense might lead us to believe that greater access to resources and manufactured products would result in a world of fewer tensions and rivalries. Observations reduce such a thought to the realm of wishful thinking.

Many of the technological advances made during our century were achieved through the development of military weapons or military defense systems.

The modern computer, advanced communication systems, radar, sonar, most of the modern aviation industry, and the space exploration program have military roots. So does the nuclear power industry.

Weapons Technology has a Long History

Throughout history many technological inventions were made for the purpose of warfare. We have presented examples earlier in our study.

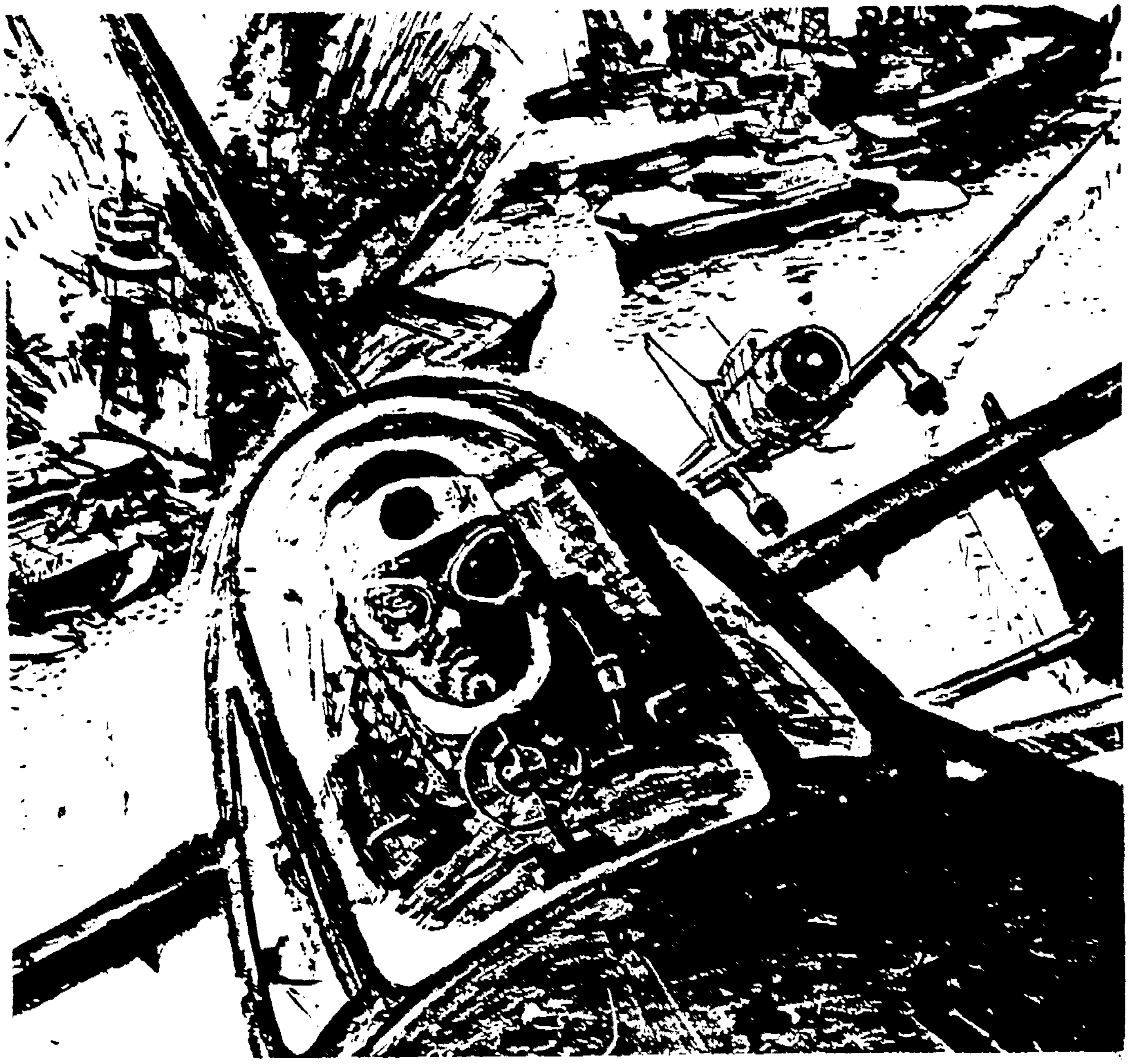
Archimedes and Leonardo da Vinci, among other things, were great military engineers. The Mongols conquered much of Asia and Europe because they had welded the horse and rider into an effective military force.

The Chinese invention, gunpowder, was developed into a destructive force with the inventions of muskets, mortars, and cannons by Europeans. These new weapons were used by the "grand monarchs" of Europe, such as Louis XIV, to expand their political power. What we now call "nations" emerged as a result.

Two World Wars

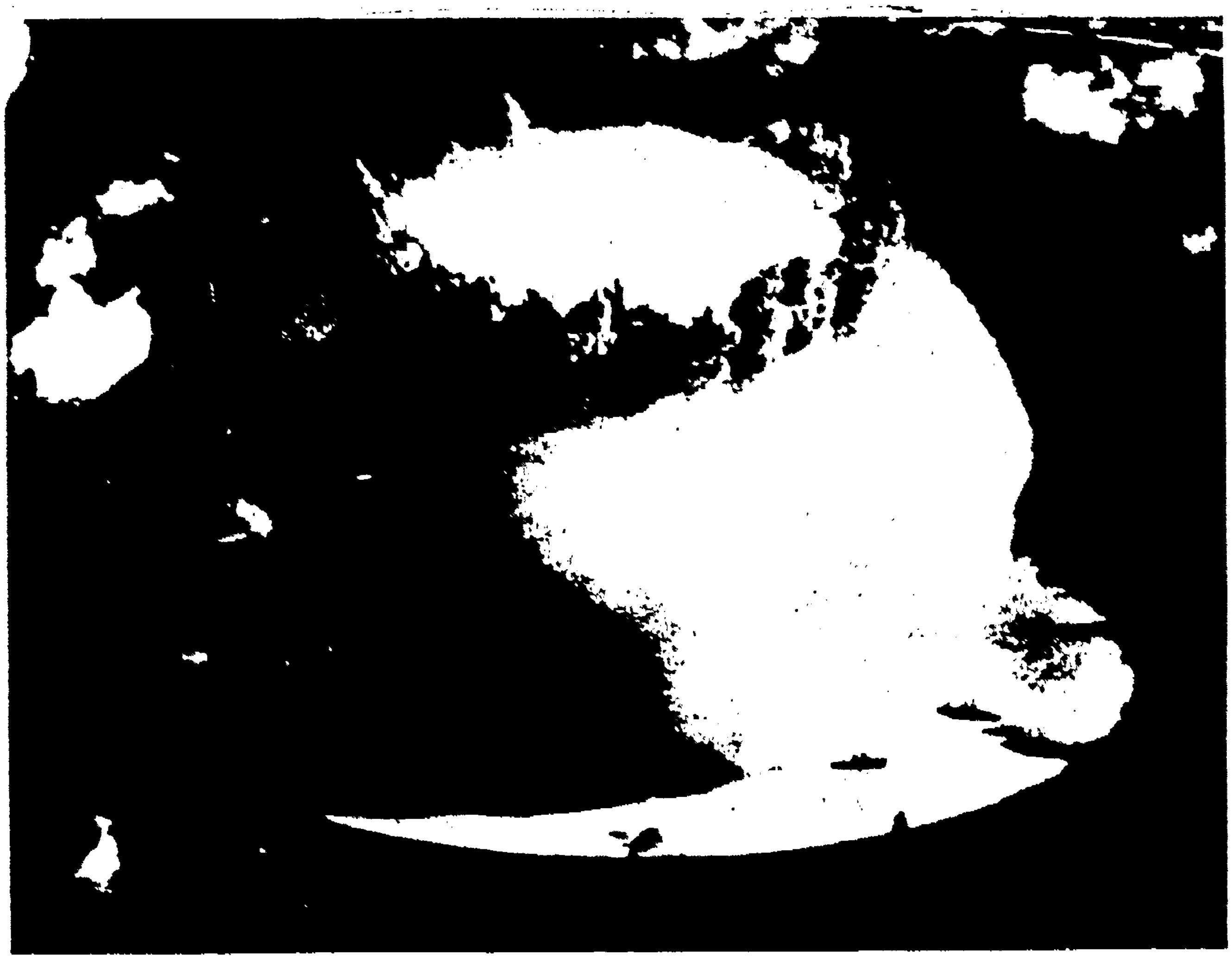
The fighting which helped form nations continued between nations. The two World Wars which were fought during the 20th century are without equal in terms of the number of people killed. This was made possible by new weapons manufactured by the powerful industries of the Industrial Revolution.

In World War I, tanks, aircraft, and poison gas were first used in warfare. Technology had provided the individual soldier with weapons which had vastly more destructive power than



Nuclear Bombs

A peak of destruction was reached in 1945 when an American "superfortress" bomber dropped a single atomic bomb on the Japanese city of Hiroshima--killing several hundred thousand people and



The terrible power of nuclear weapons has exerted enormous influence on international affairs, national policies, and the minds of individuals ever since the explosion of the first atomic bomb in 1945. Here, the blast of an atomic bomb at Bikini atoll makes toys of American warships moored in the test area. The atomic bomb was to be dwarfed in power by the hydrogen bomb.

shocking the world into a new era. A Japanese newspaperman who was an eyewitness described the event:

> Suddenly a glaring whitish pink light appeared in the sky accompanied by an unnatural tremor which was followed almost immediately by a wave of suffocating heat and wind which swept everything in its path... Within a few seconds the thousands

of people in the streets and the gardens in the center of the town were scorched by a wave of searing heat. Many were killed instantly, others lay writhing on the ground screaming in agony from the intolerable pain of their burns. Everything standing upright in the way of the blast--walls, houses, factories and other buildings--was annihilated and the debris spun around in a whirlwind and was carried up into the air. (quoted in *WWII*, by James Jones, page 248)

An Arms Race

Arms races of the past never matched the fearsome competition between the Soviet Union and the United States to create and stock pile intercontinental ballistic missiles capable of hurtling thousands of miles at fantastic speeds and utterly destroying whole cities at a single blow. Here, at an early stage in its development, is America's enormous Titan.

As you probably know, the United States and Russia are currently leading the world in an arms race. Growing arsenals on both sides and massive exports of weapons have brought the nations of the world into a precarious balance of extraordinary power. This power could conceivably destroy all life on the planet.

According to the U.S. Navy, when speaking of the new Trident submarines, "Each Ohio class submarine represents by itself more explosive power than what was fired by all the world's navies in all the wars in history." The comander of the Trident submarine has at his fingertips the power to destroy or severely damage every large and medium-sized city in the Soviet Union.

The Soviets have weapons of similar capability poised at Europe and the United States.

Meanwhile, many other nations of the world are developing weapons industries, both nuclear and conventional (non-nuclear).

'Each Ohio (Trident) class submarine represents by itself more explosive power than what was fired by all the world's navies in all the wars in history.' — U.S. Navy

The three-pronged spear — trident — carried by King Neptune, god of the sea in Roman mythology, symbolized his strength. Since then the trident has come to be seen as a symbol of naval power.

The name is applied to the U.S. Navy's newest weapons system: the three-part combination of Trident long-range nuclear missile, the huge Ohio class nuclear submarine, and the shore support base specifically designed to service and maintain the Trident missile submarine and provide shore support for crew and dependents.

• The submarine. Displacement, tons: 16,600 surfaced, 18,700 dived. Dimensions in feet, 560 long, 42 beam, draws 35½ feet. Propulsion, one pressurized-water cooled General Electric nuclear reactor, 60,000 horsepower. Missiles, 24 Trident I. Torpedoes, four bow tubes. Crew, 140 enlisted and 14 officers. Speed, submerged, about 30 knots (35 miles an hour). Range, indefinite. 400,000 miles before nuclear refueling necessary. Total operational cost, $1.2 billion.

• The missile. Trident I, range about 4,000 statute miles. A three-stage solid fuel rocket weighing about 65,000 pounds, 34 feet long, diameter 74 inches. Number of separate, independently targetable re-entry vehicles (hydrogen bombs) in each warhead is classified, but estimates range from 8 to 14 per missile. Explosive yield per bomb also classified, but said to be in 100 kiloton range. Missile speed supersonic, details classified. Accuracy same as Poseidon, which means ideally within a few hundred yards of bullseye. Cost, $12.1 million.

• The base. Equipped to meet virtually all needs of Trident missile system, including fabrication and loading of missiles, crew training, full refit of submarines with exception of major overhaul and nuclear reactor refueling, provisioning and maintenance of submarines, full support facilities for crewmen while ashore and crew families, include living quarters, shopping center, school, and amenities ranging from library to saunas and bowling alleys. Cost, $800 million.

Weapons Industry:
A Drain on the World Economy

The military industry is the largest and the fastest-growing industry in the world. Though it is often seen as an important source of technological innovation and of jobs, there is no denying that it is a great drain on human labor and natural resources.

The 1983 defense budget in the United States was $239 billion dollars. With a U.S. population of 235 million people, this amounted to $1017 per person for that year. This figure does not include the amount of labor and other resources which went into the making of weapons for the large export market.

Weapons and Industrial Systems: Automation

In 1983, U.S. defense officials were worried about industrial capabilities in our nation. Japan was seen as outcompeting U.S. industries, especially in the production of steel and in the use of industrial *robotics*--automated assembly-line machines, which are usually controlled by computers.

At a meeting between military personnel and a group of industrialists called the Manufacturing Technology Advisory Group, General Larry Skantze expressed a concern:

> Since our war-fighting equipment comes from the industrial base, the condition within that base must be addressed and corrected....
>
> We plan to maximize application of mechanization and automation and we plan a paper-free factory with planning, scheduling and control by the latest computer hardware and software techniques. We thus expect the factory that can perform at least one full shift per day, unmanned.

A workerless factory raises many questions about the future of work in this country. But at the meeting there was little said of the social consequences of automation.

Brian Moriarty directs industrial automation experiments at a Massachusetts research lab--a lab with 90% of its funding from the U.S. Department of Defense. When questioned about the industrial automation being developed for the military, he responded with the following statement:

> I guess we're basically engineers and as engineers we deal with engineering problems. We're not social scientists; we don't see

ourselves like that and we're probably very uncomfortable dealing with social issues, in dealing with the idea of workers being displaced. We don't like to think about families on welfare--that kind of thing.

In the next lesson, and in other parts of this course, we will discuss the technologies of automation.

COMPLETE THE FOLLOWING WORKSHEET.

"Want To Know How It Ends?"

from Herblock's *Special For Today* (Simon & Schuster, 1958)

"Herblock" cartoons, in which the Bomb is personified as a cynical, brutish enemy of all mankind, have served as repeated reminders of the ever present danger of annihilation through nuclear war. How to end this danger is the overriding problem facing civilization itself at the present time.

WORKSHEET

LESSON 9

1) Describe the relationship between energy and economic growth which characterized the years 1950 to 1973.

2) Do you find the relationship between technology and warfare which is presented in this lesson to be unusual? Why or why not?

3) Do you agree with George Washington's statement: "To be prepared for war is the most effectual means of preserving the peace."? Why or why not?

4) How can a community, a state, or a nation be prepared for war?

5) Often appropriate technology is viewed as a type of "defense." Self-reliance can be a defensive strategy. Also, the development of industries which are not heavily dependent on imported resources and export markets are measures which can reduce international tensions. Do you think that this "appropriate technology civil defense strategy" is worth considering? Why or why not?

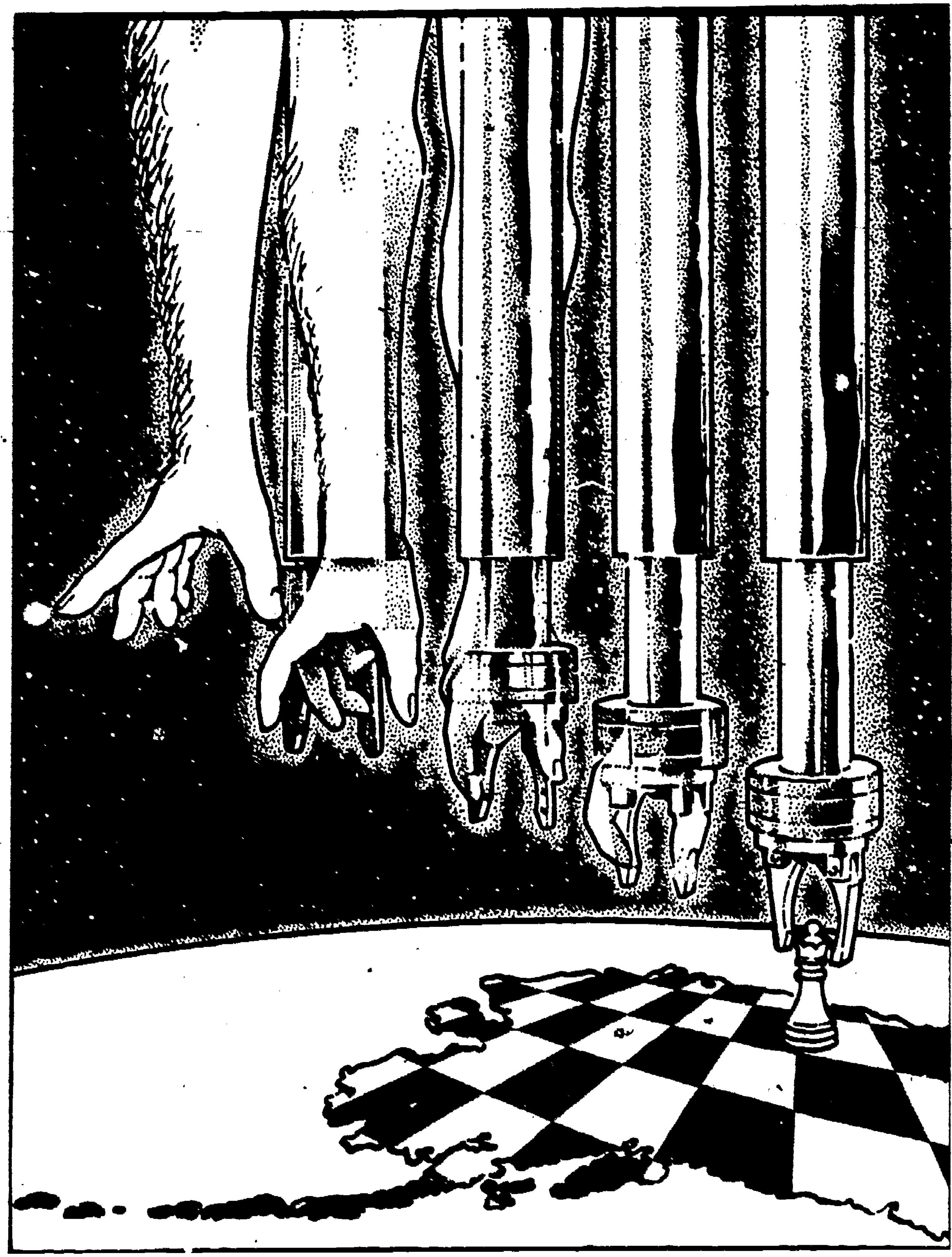
6) Describe some uses of technology which you feel would best prepare Alaskans for times of war.

7) What role does energy have to play in defense and war?

8) Why do you think that Alaska is often spoken of as being "strategically important" to the welfare of the United States? [A dictionary might be helpful for answering this question.]

A HISTORY OF TECHNOLOGY

LESSON 10



A HISTORY OF TECHNOLOGY

LESSON 10

AUTOMATION

Whereas the tool is precisely an "extension of the hand," the simplest machine already contains some measure of automation.

Witold Rybczynski
Paper Heroes

There has been only one industrial revolution, and that consisted of the replacement of human muscle as a source of energy. And, there is a second revolution in the making whose object is the replacement of the human brain.

Norbert Wiener
The Technological Society

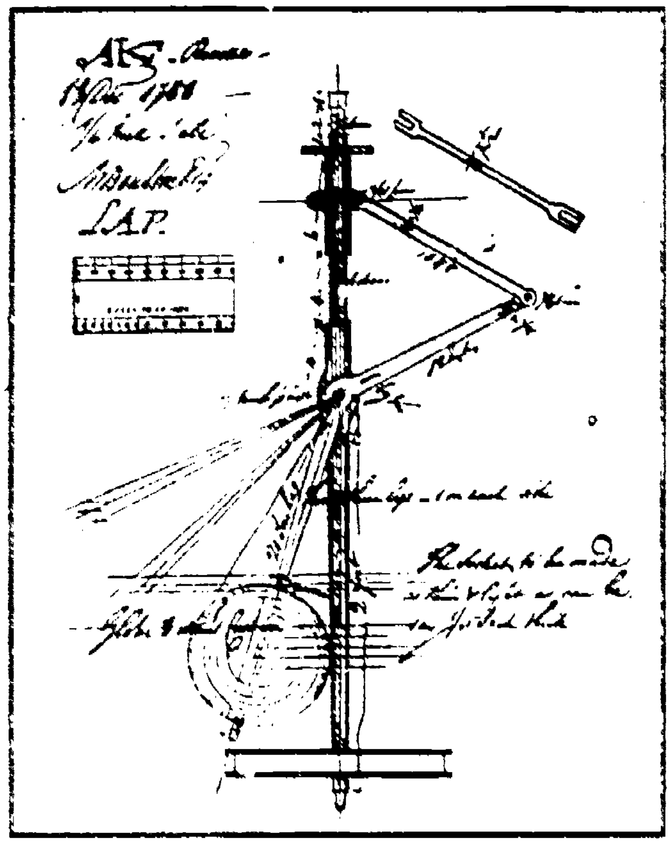
INTRODUCTION

With this lesson we complete the presentation of a general history of technology.

It is much easier to look back in time to pick out the important events and developments of an era. It is harder to discern the key features of the age we live in.

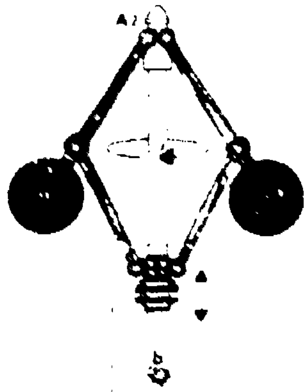
We, the authors of this course, feel that the technological revolution of automation--computers and robots--will be amongst the most important developments for the society of the near-future. Therefore, before examining the history of technology in

Alaska, we end our general historical presentation with a lesson about automation.



A1

A2



A Watt did not invent the centrifugal governor but he was the first to use such a construction to automatically regulate a steam engine. This occurred in 1788, and in November of that year, a drawing (1) of such a governor was entered in Boulton & Watt's "Drawing Day Book", where a running account of the work done in the company's drawing office was kept. Watt's centrifugal governor (2) consisted of two pendulums equipped with weights (a) and mounted on the output shaft (b) of the steam engine. The governor's function was based on the fact that the speed of the steam-engine tended to increase when its work load was decreased, whereas the speed decreased when the work load increased. Because of the action of the centrifugal force, the weights swung further and further outwards the faster the regulator revolved. A sliding collar (c) was then brought upwards and pulled with it a rod which, directly or indirectly, regulated the steam supply to the engine.

AUTOMATION

The development of automation in the 20th century is probably of the same level of importance in the growth of technology as any of the stages we have already discussed. A current trend in technology is to automate the work which has been done by people.

A familiar example of automation is the household thermostat. It controls the furnace by tuning it on and off, automatically. The setting of a desired temperature "programs" the thermostat.

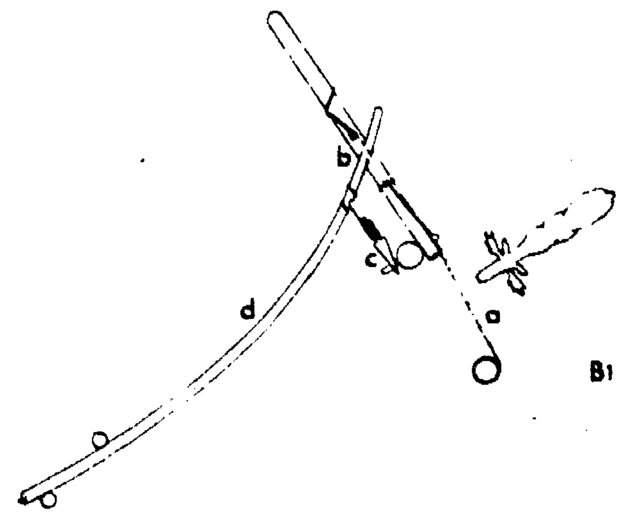
Another example of automation brings us back to the early days of the Industrial Revolution. One of the reasons for the success of the Watt steam engine was the use of a device to automatically control or govern the speed of the engine. The importance of this device, called a "centrifugal governor," is probably what prompted Boulton and Watt to keep its design secret for many years. When the patent expired in 1800, the centrifugal governor became standard equipment on most steam engines. Today the principle of this automatic control device is applied in a number of different machines.

Examples of Ancient Automation

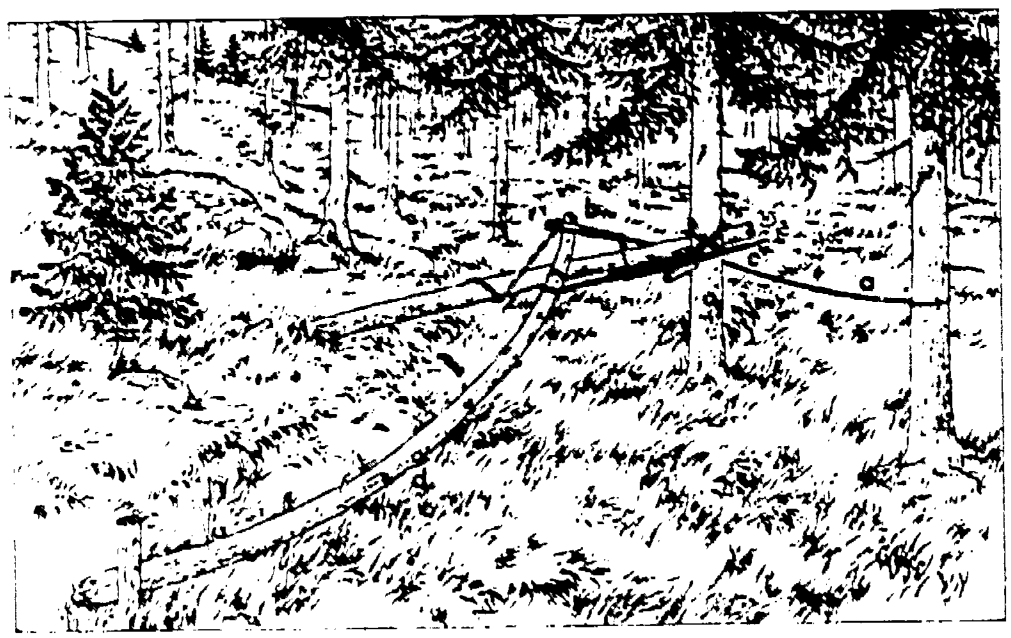
Automated technologies have existed for thousands of years. A method of cooking used by hunters in North Africa about 6650 B.C. is a good example of automation. Food was placed in a leather bag along with a stone that had been preheated in a fire. The stone was

chosen if it was large enough to provide enough cooking time for the food. For this device, selecting the size of the stone for the desired cooking time provided the choice of program--much like the use of an electric timer on a modern kitchen range.

Ten thousand years ago, hunters were catching animals in an automated device called a gin trap. The "moose spear" is a gin trap which originated in ancient Scandanavia and was used well into the 20th century. It's automatic firing mechanism caused the spring action of a young tree to propel a spear into a moose, triggered by the breaking of a line by the moose.



B1



B2

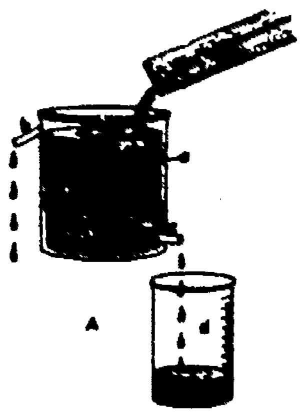
B A moose spear is shown here from above (1) and from the side (2). When the moose moved against a line (a), a catch (b) was released. The spear (c), which was mounted on a young tree-trunk under tension, was then flung forwards and buried itself in the moose.

The ancient gin trap has its counterpart in modern times. The "Jack in the Box," used in Vietnam, worked very much like the moose trap, with a hand-grenade substituting for the spear.

Greek Contributions to Automation

The Greeks of Alexandria experimented with automation. We already discussed some of the devices invented by Hero. His mechanism for opening the temple door certainly was a

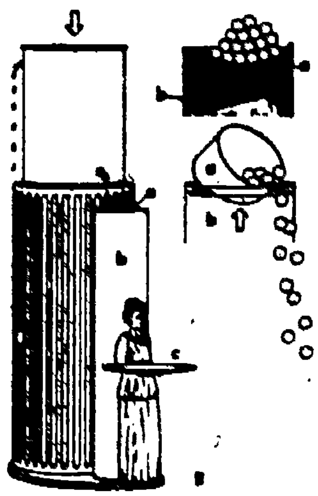
form of automation, though spectators probably thought that the door was powered by a supernatural force. Another of Hero's inventions was used to control the level of a fluid, operating on the same principle as the modern flush toilet and other hydraulic devices.



A The simplest type of water clock consisted of a vessel (a) with an overflow (b). From the lower part of this vessel, water dripped through a tube (c) and into another, graded vessel (d). Since the water constantly supplied to a amounted to a little more than the amount of water dripping out through c, the water pressure in a was approximately constant.

Clocks Played a Major Role in the Development of Automation

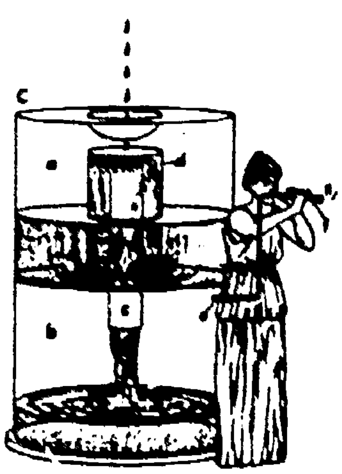
Hero's teacher, Ctesibius developed the "clepsydra," a water clock which was in common use in ancient Greece. Plato, the great philosopher from Athens, gave the clepsydra another automatic function. The pupils of his academy in Athens in 378 B.C. were awakened one morning by a magnificent alarm clock. Plato had modified the clock so that as the clock's vessel filled with water during the night, a bowl was lifted, which in due time caused lead balls to roll out and fall on a copper plate. The noise probably sounded something like thunder.



B Plato's alarm clock was a simple clepsydra, in which a bowl (a) containing lead balls had been hinged to the brim of a (usually) graded vessel (b). When the water level in b had risen enough, the bowl was lifted, and the lead balls were tipped out and fell onto a copper plate (c).

The engineers of the Arab world carried on where the Greeks left off.

> In the fifth century AD, a magnificent ornamental clock was built in Ghaza. This clock was very similar to the mechanical astronomical clocks which became status symbols in European cathedrals and town halls from the fourteenth century onward...The components used in the Ghaza clock were the same as those used by Hero...The Ghaza clock became very famous and, for centuries, inspired other designers to similar achievements. (*History of the Machine*, page 47)



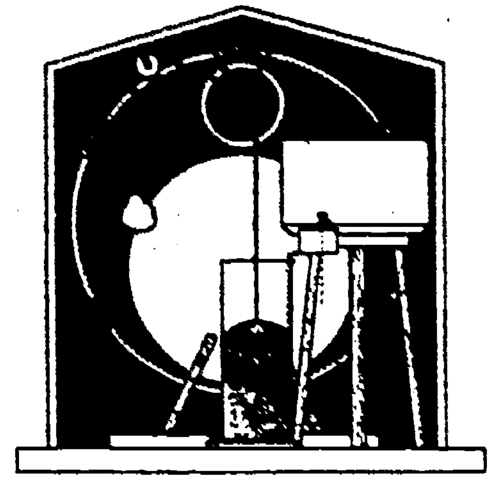
C This clepsydra with its signalling device has also been attributed to Plato. The water from the clepsydra was collected in a vessel which was divided into an upper (a) and a lower (b) compartment. Between these ran a pipe (c) which was open at both ends. Vaulted over pipe c was a wider pipe (d) whose closed upper end was situated a short distance above the top of the inner pipe, whereas its open, lower end had been designed so that water could enter between the two pipes. When the water in a had risen above the upper edge of the inner tube (c), a was fairly rapidly emptied of water, which ran into b, since the two pipes together worked as a siphon. The air in b was then compressed and forced out through a pipe (e), to whose outer end a flute (f) was attached.

The mechanical clock, a technological descendant of ancient

machine elements, first appeared in the cathedrals and monestaries of 14th century Europe. With the widespread adoption of this automated time-keeper, a new regularity of human society came into being, governed by a machine.

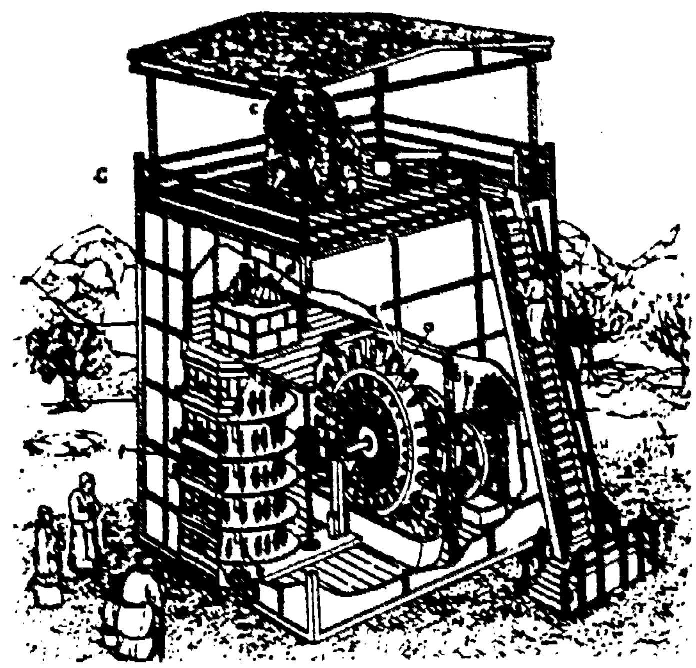
> It would be no exaggeration to say that the monestaries helped to give human enterprises the regular, collective pulse and rhythm of a machine. A clock not only helps to keep track of the hours, but also synchronizes the actions of man...The instrument rapidly spread beyond the monestary, and the regular striki.. gave new regularity to the craftman's and merchant's lives. The measuring of time turned into time slavery, time estimating and time rationing. When this happened, eternity gradually stopped to be the yardstick and the aim of people's actions. The clock, not the steam engine, is the key machine of the modern industrial age. (*Technics and Civilization*, Lewis Mumford, page 51)

By the middle of the sixteenth century, the development of clocks had stimulated craftsmen to refine their methods, develop new tools, and invent new machine elements. The appearance of the pocket watch challenged craftsmen working in precision mechanics to develop even more precise and still smaller machine elements. The new mover, the spring-driven clockwork of the watch, was soon used to power automatic devices of various kinds. By the middle of the 19th century, mechanical toys were being driven by springs.



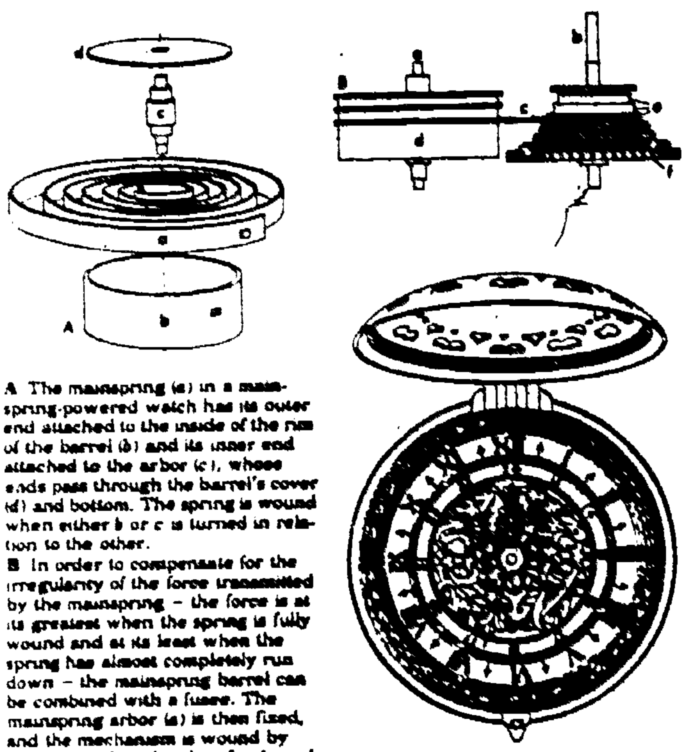
B

B A reconstruction of a 6-ft (2 m) high Roman clock.
C A reconstruction of an approximately 40-ft (12 m) high astronomical clocktower, which was built in c. 1090 AD in the Chinese city of Honan by one Su-Sung. The clockwork was driven by a water-wheel (a), whose ladles were filled with water from a tub (b). An ingenious device prevented the water-wheel from turning while each ladle was being filled. The water-wheel also rotated a bronze planetarium (c) and a celestial globe (d). A series of automata (e) indicated the passage of time by appearing in niches (f) and striking bells and gongs.



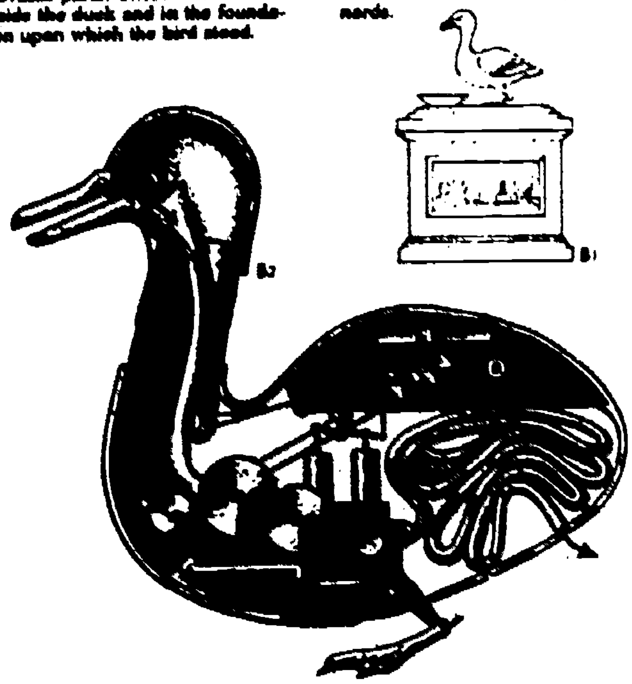
From Mechanical Toys to Automation in Industry

The French played a major role in the development of automation. Some of the automatic devices made by Jacques de Vaucanson, mostly to tickle the fancy of European royalty, represent a high point of this kind of development. One of his devices was a mechanical duck which could walk in the wagging way of a duck, eat and digest fish, and excrete the remains in the "natural" way.



A The mainspring (a) in a mainspring-powered watch has its outer end attached to the inside of the rim of the barrel (b) and its inner end attached to the arbor (c), whose ends pass through the barrel's cover (d) and bottom. The spring is wound when either b or c is turned in relation to the other.
B In order to compensate for the irregularity of the force transmitted by the mainspring – the force is at its greatest when the spring is fully wound and at its least when the spring has almost completely run down – the mainspring barrel can be combined with a fusee. The mainspring arbor (a) is then fixed, and the mechanism is wound by turning the fusee's arbor (b). A cord (c), one end of which is attached to the barrel (d), will then be wound onto the fusee's spiral groove (e); simultaneously, the barrel will be turned.

B Vaucanson's famous duck (1) had a weight-powered mechanism which consisted of over a thousand movable parts. These were hidden inside the duck and in the foundation upon which the bird stood. Unfortunately, the duck has now been lost. Some illustrations depicting it survive, however, among them this one (2), showing its innards.



Vaucanson's toys became very popular and made him a wealthy man. Along the way he made some important contributions to the development of technology. To produce his highly complicated mechanisms he had to design a precision lathe to cut screw threads. He was also the first person to use rubber to make a hose, which he invented while searching for a suitable material for the mechanical duck's intestines.

Sometime during the middle of the 18th century, Vaucanson stopped making toys and became director of silk mills

in Lyons, France. He applied what he had learned from making mechanical toys to industry by improving the semi-automatic devices for controlling fancy silk-weaving looms--making them fully automatic. He did this by controlling the movements of the looms with punched cards or endless paper tapes with holes punched in a sequence which programmed each step of the weaving process.

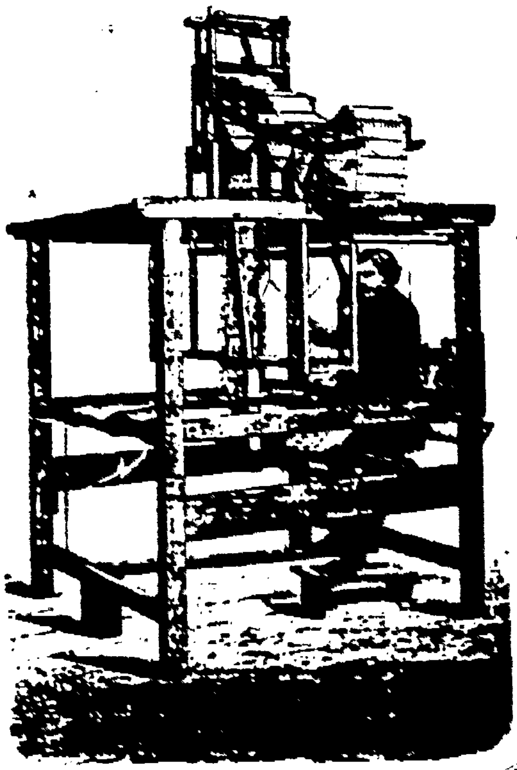
In 1805 Joseph Marie Jacquard combined his experience as a child working in the silk mills with the knowledge he had gained from Vaucanson and others. He produced the first commercially successful automated silk-weaving loom. By 1812 ten thousand Jacquard machines were operating in France.

An Early Mechanical Computer

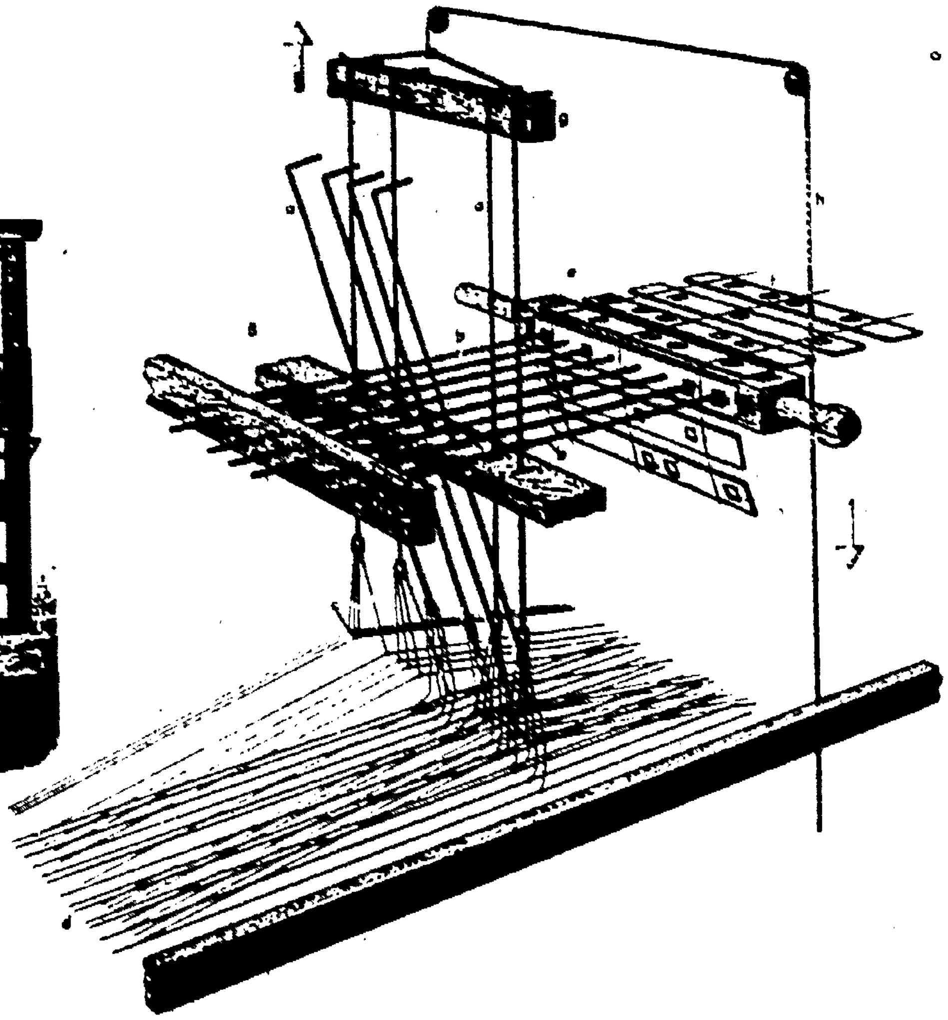
By the end of the nineteenth century, the idea of using punched cards to control machinery was applied by Herman Hollerith (1860-1929) to help the United States Census Bureau.

Hollerith, an employee of the Bureau, introduced a rectangular card divided into 240 squares. In each square a hole could be punched, according to a code corresponding to questions. A punched square represented the answer "yes," while and unpunched square meant "no." One card could contain information about a person's age, sex, and so on. The punching was done manually, one card per person, but the cards were read by a machine.

The census of 1880 had taken seven years to complete, the population then numbering over 50 million. The 1890 census, taking a little over two years to complete using Hollerith's cards, revealed that the population had increased to 63 million.



A Jacquard's automatic draw-loom was invented in 1806. As compared to earlier mechanisms, Jaquard's construction was relatively simple, a fact which contributed to its success.



B A simplified explanatory sketch of Jacquard's automatic draw-loom. The vertical hooks (a) ran through eyes in spring-loaded needles (b). At the bottom end of the hooks were bunches of strings, which carried the heddles (c). Through these ran the warp threads (d), which were distributed among the needles according to the pattern. The needles bore on a hollowed-out, square-section roller (e), over which an endless chain of punched cards (f) ran. Every time the weaver pushed a foot-pedal downwards, the roller was rotated one-fourth of a revolution, and a new punched card was pulled forward. At the same time, the griff (g) was raised, pulling with it the hooks whose needles had been able to enter the roller through the holes in the punched card. All other needles were pulled backwards. (h) Pedal rope. The Jacquard looms could have very large numbers of hooks, and at the end of the nineteenth century, looms with four hundred and six hundred hooks were the commonest.

C Hollerith's reading machine for punched cards was originally battery-powered. The cards were hand-fed into the machine, where brush contacts were run across them. Inside the roller were mercury containers, one for each row of holes, and when contact was made, an electric circuit was closed. The circuit either sent impulses to a tabulator's counting device or decided which way the card was to take in order to land in the correct box in a sorting machine. This illustration is based on a drawing in Hollerith's patent application of 1889.

Hollerith further developed his methods and started his own company which produced punch-card machines that performed bookkeeping and statistical functions. His company flourished and became one of the cornerstones of the International Business Machines Corporation, IBM, which was founded in 1912. Today IBM is one of the largest corporations in the world.

The Development of Electronic Computers

By the time computers began to appear, sometime around 1946, there already was a well-developed technology of information gathering, making use of punch cards and tapes. The "punched" or "not punched" system was well suited to the electronic language of the computer's binary system.

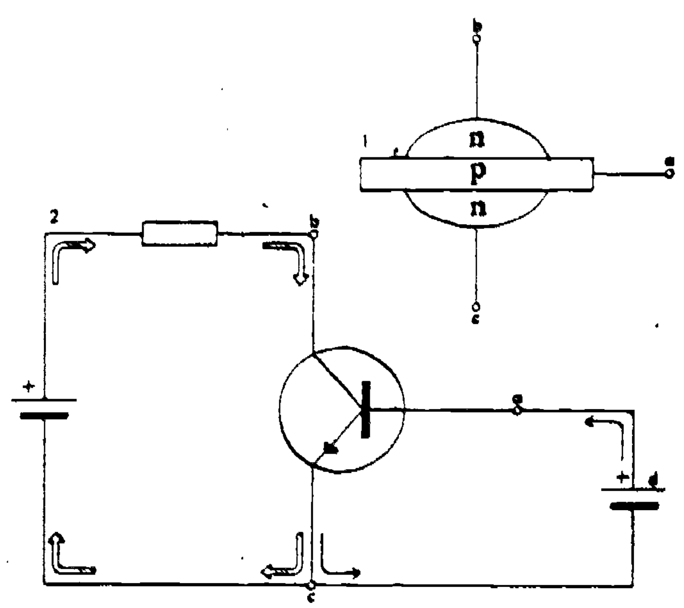
The binary system is quite simple and is at the heart of how most modern computers work. "Binary" means "two numbers" in Latin. Information is stored in on/off electronic components, which are very much like the "punched"/"not punched" storage system of the cards and paper tapes. Hollerith's cards and tapes were used to put information into the early computers.

Advances in computer technology have been made primarily by increasing the speed of computer operation and reducing costs, often by making circuits and other electronic components smaller.

The first important step in the process of miniaturization of the computer was the development of the transistor, which some people say is one of the greatest technological achievements of the 20th century. The early transistor, which was no bigger than the head of a match, could transfer information faster than the relays and vacuum tubes it replaced. It was also less expensive and more durable than the fragile glass tubes.

The word "transistor" is a combination of two words, "transfer" and "resistor." It can either conduct electricity (transfer it) or not conduct electricity (resist it) and it can change from one of these states to the other billions of times a second. Because the materials of which transistors are made have this dual nature, capable of both resisting and

A transistor consists of semi-conductor crystals and is, in its original form (1), built like a hamburger in a roll. The hamburger (a) is a p-crystal, whereas the roll (b, c) consists of n-crystals. (2) A transistor circuit. If a battery (d) is connected to the transistor's base (a) and to its emitter (c), so that a positive voltage is applied to the base, electrons are brought from the lower n-crystal (c) through the p-crystal (a) and over to the upper n-crystal (b), the collector. A current then flows through the left-hand circuit. However, if a negative voltage is applied to a, the current in the outer circuit is stopped.



conducting electricity, they are often referred to as "semi-conductors."

The research team which developed the transistor, John Bardeen and Walter Houser of Great Britain and William Shockley of the Bell Telephone Laboratories in the United States, shared the 1956 Nobel prize in physics for their discovery.

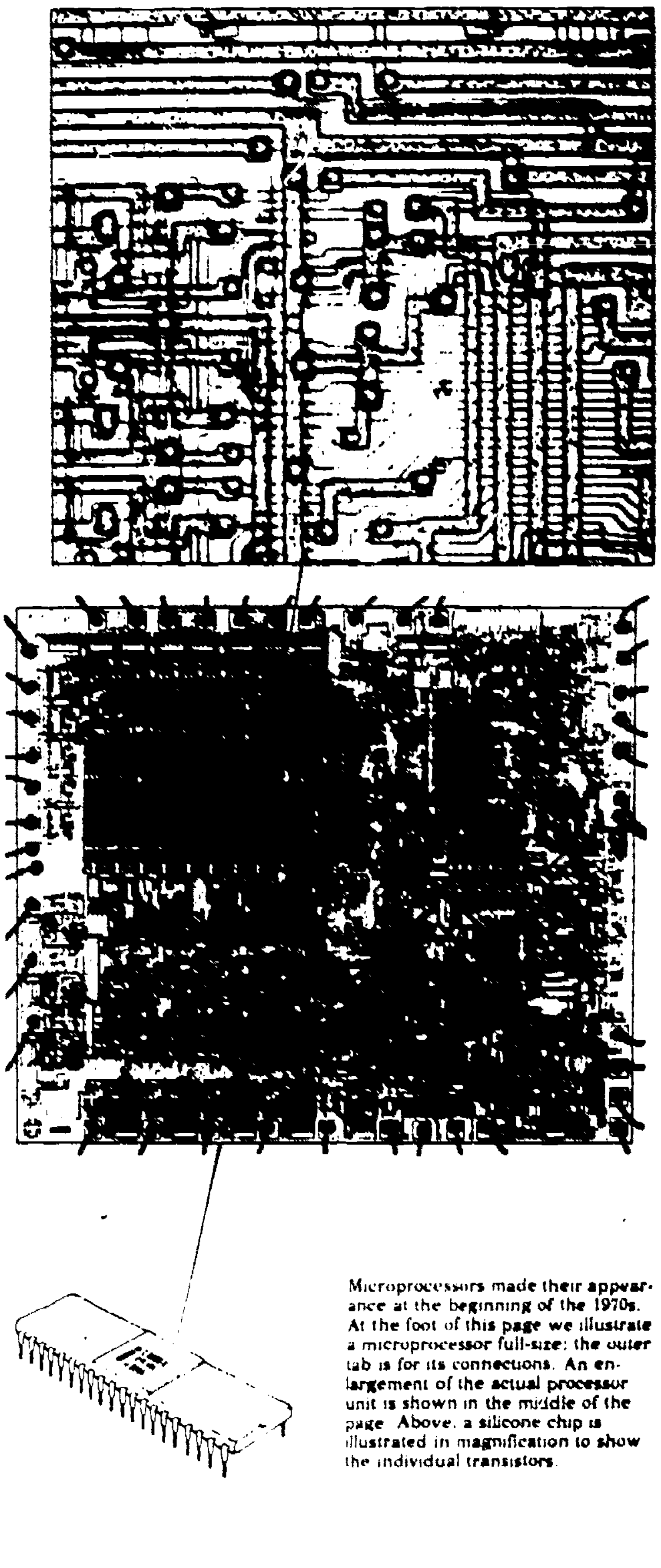
Integrated Circuits on Silicon "Chips"

During the early 1960's there was a lot of talk about developing a gigantic computer that would be the central element in a massive network of terminals. Many companies would subscribe to the services of the central computer, much the way a water or electric utility functions today. This plan of action made sense because the early computers were huge and cost great sums of money.

The introduction of a new electronic component, the integrated circuit, helped to displace many of the large computers. Integrated circuits consist of transistors and other circuit components "printed" onto a semi-conductor crystal, usually made of silicon--the socalled silicon "chip." A typical chip is about the size of a thumbnail, and contains thousands of transistors, all intricately connected with "wires."

These components and wires are made by infusing the silicon or other semi-conductor material with various chemicals. This is done by many careful and tedious steps, such as masking (as you would mask the chrome of a car while painting the body) and placing the chip into a hot oven which has chemicals in the air. The chemicals "melt" into the exposed areas of the chips.

IC (integrated circuits) computers are generally called third generation computers and with them a new era begins. The revolution in computer technology can be compared to the revolution that took place in engineering workshops in the early 1900's. Up to then, all machine tools, such as lathes, drills, etc., had been driven by a central steam engine, with power transmitted by belts, but at the beginning of the century, electric motors were introduced, allowing each machine to be worked individually. In much the same way, the central "steam computers" with their large network of terminals were gradually replaced by smaller computers placed where they were needed, a development that accelerated in the 1970's. (*A History of the Machine*, page 197)



Microprocessors made their appearance at the beginning of the 1970s. At the foot of this page we illustrate a microprocessor full-size; the outer tab is for its connections. An enlargement of the actual processor unit is shown in the middle of the page. Above, a silicone chip is illustrated in magnification to show the individual transistors.

Computer Design and the Microprocessor

By the late 1960's, computers were being used to design other computers. This process continues to be one of the most important areas of computer-engineering research, as computers become more and more capable of designing themselves. As this course is being written in 1983, the U.S. government has pinpointed this type of research as strategically important for economic and military security.

In 1971 the microprocessor took the world by surprise. The microprocessor is a chip which can do all the main functions of the central processing unit of a computer. It very quickly led to the development of industrial control systems and the pocket calculator. A more recent development, already revolutionizing

businesses, schools, and homes, is the microcomputer.

This course is being written on an inexpensive, portable microcomputer which weighs a little more than twenty pounds. It comes equipped with a video screen, a microprocessor, about 65,000 "bits" of memory in the internal memory (a bit is one "on/off" switch, which is one transistor on a chip), and two disc drives which store and retrieve about a million and a half bits of information. It also comes with sophisticated word-processing software, which is a program that allows the writer to store words, erase, move sentences around, etc.

Hardly a day seems to go by without hearing of some new application of microcircuit technology. Electronic watches, video games, and electronically controlled household appliances are but a few of the applications we see around us. The industrial robot, though not as visible to most of us, is another child of the microprocessor.

Robots and Cybernetics

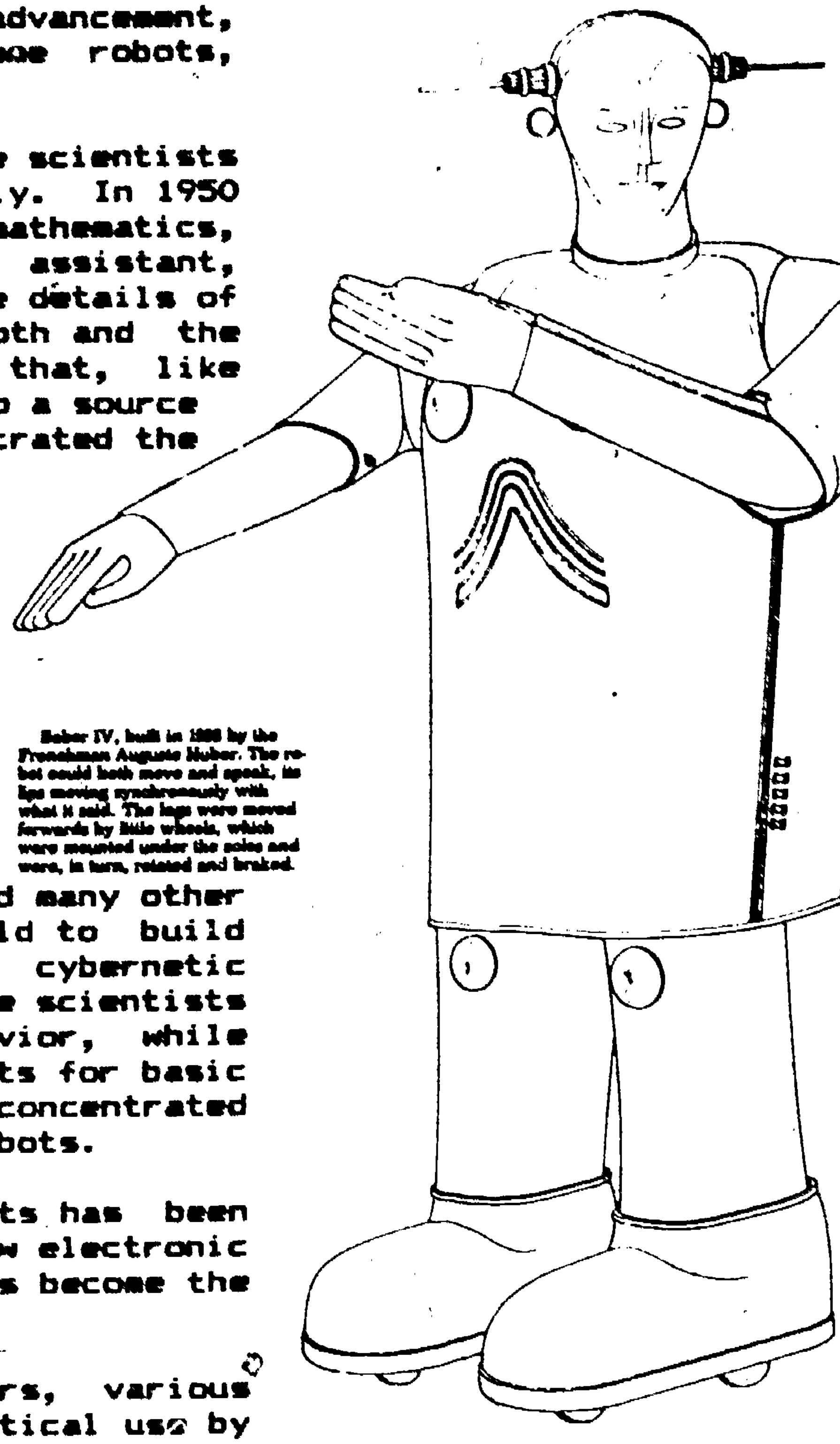
In 1920 the Czech playwright, Karel Capek, presented his play *R.U.R.* (Rossum's Universal Robots), giving birth to the word "robot." The origin of the name is the Czech word "robota," which means compulsory or slave labor. Soon robots were appearing in popular literature and in movies. At the 1939 World's Fair in New York, a walking and talking robot named Electro appeared with its dog, Sparko. Sparko, also a robot could run, bark, and sit up and beg at the command of its master.

Robots, popularly thought of as "artificial" people or animals, are broadly defined as any machine or device that works automatically or by remote control. Some robots do simple tasks repeatedly, while more sophisticated

robots can be programmed to do a variety of tasks. Another level of advancement, already incorporated into some robots, is the ability to learn.

After World War II some scientists began to take robots seriously. In 1950 an American professor of mathematics, Norbert Wiener, and his assistant, Jerome Wiesner, published the details of a robot they called "the moth and the light," which was a machine that, like a moth, could be attracted to a source of light. This robot demonstrated the "cybernetic process."

Wiener developed "cybernetics", which is the science of the mechanisms that control and regulate animals and machines. He coined the term from the Greek word "kubernetes," which means "someone who steers."



Huber IV, built in [illegible] by the Frenchman Auguste Huber. The robot could both move and speak, its lips moving synchronously with what it said. The legs were moved forwards by little wheels, which were mounted under the soles and were, in turn, rotated and braked.

Wiener's work stimulated many other scientists all over the world to build robots and to perform cybernetic experiments. Some of these scientists experimented with human behavior, while others built laboratory robots for basic research, and still others concentrated on the industrial uses of robots.

The development of robots has been greatly influenced by the new electronic technology. The computer has become the brain of modern robots.

During the last ten years, various robots have been put to practical use by industry—replacing humans on the assembly line. So far, most working robots have been limited to the automobile industry.

The Olympian, Thursday, October 21, 1982 A12

The Northwest

Robot tackles Rubik Cube

RICHLAND, Wash. (AP) — Scientists at Battelle Northwest Laboratories here have been doing some puzzling research with an unusual twist.

They call the result Cubot, a 70-pound robot which can solve Rubik's Cube.

Team spokesman Michael Lind said Wednesday the robot was built for fun, but it also shows off Battelle's ability to integrate sophisticated technologies in an intelligent robot.

Cubot can solve any scrambled Rubik's Cube in less than four minutes.

The team is working to get that down under two minutes, Lind said.

The human record is 16 seconds, Lind said, but most people skilled at the puzzle take from one to five minutes to solve it.

Lind said the technology involved has dozens of industrial applications, especially in manufacturing where sorting and assembly are required.

The robot can even be programmed to handle performance and quality inspection tasks, he said.

Robot Industry in the United States

In 1979, total robot sales in the United States brought companies $60 million, for 1000 robots. In 1981, 2100 robots sold for $151 million. One industry analyst predicts that 1985 sales to be $540 million, with robotics industries churning out over 8000 robots in that year.

David Cook, business correspondent for a newspaper, the *Christian Science Monitor*, has made note of the fact that big companies are showing an increased interest in the robot industry.

> When robot inventor George Devol tried to drum up interest in his labor-saving device in the 1950's, he got the cold shoulder from big business.
>
> "They said, 'Who needs it?' recalled the white-haired grandfather of the robot industry.

And for almost 30 years corporate giants continued to act as if robot manufacturing should be left to small companies which presumably had nothing better to do. As a result, the largest factor in the US robot industry has been Unimation Inc., which had 1981 sales of around $57 million.

But now the heavy hitters of American industry have changed their minds about the robot's prospects. While 1981 robot sales were a tiny $151 million, robot industry revenues are projected to grow at a 35 percent annual rate through 1990. Much of the factory equipment for the 1980's and 1990's is expected to be built around robots.

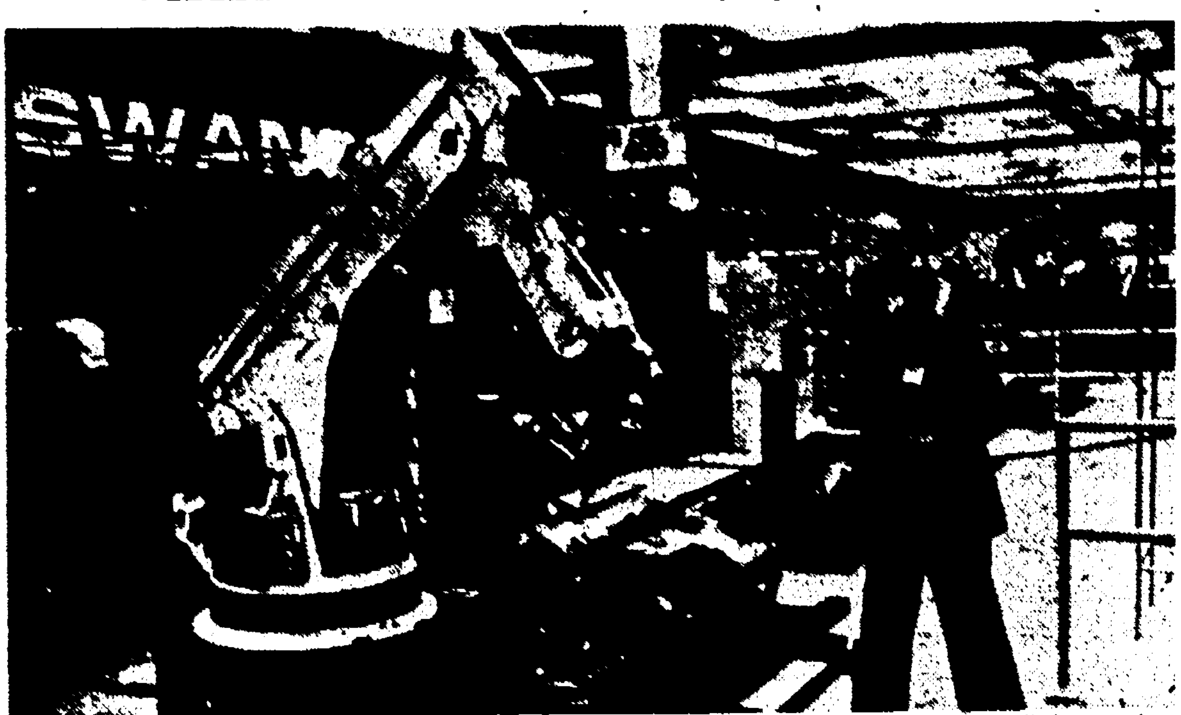


Photo by Barth Falkenberg, staff photographer

General Electric and other robotmakers show products in Detroit

Friday, March 5, 1982

Robot business takes off

	Sales revenues (millions of dollars)	Units sold
1979	$ 60	1,000
1980	$100	1,450
1981	$155	2,100
1982	$215*	3,100*
1983	$280*	4,100*
1984	$395*	5,900*
1985	$540*	8,100*

*Estimates

Source: Bache Halsey Stuart Shields Inc.

CHRISTIAN SCIENCE MONITOR

International Business Machines Corporation [IBM] provides perhaps the most convincing sign that robots now appeal to corporate titans. A few days ago the world's largest computer company unveiled its first two entries in the robot derby. IBM is hot on the heels of other sizable newcomers to

robotmaking, including Westinghouse Electric Corporation, General Electric Company, and Bendix Corporation...

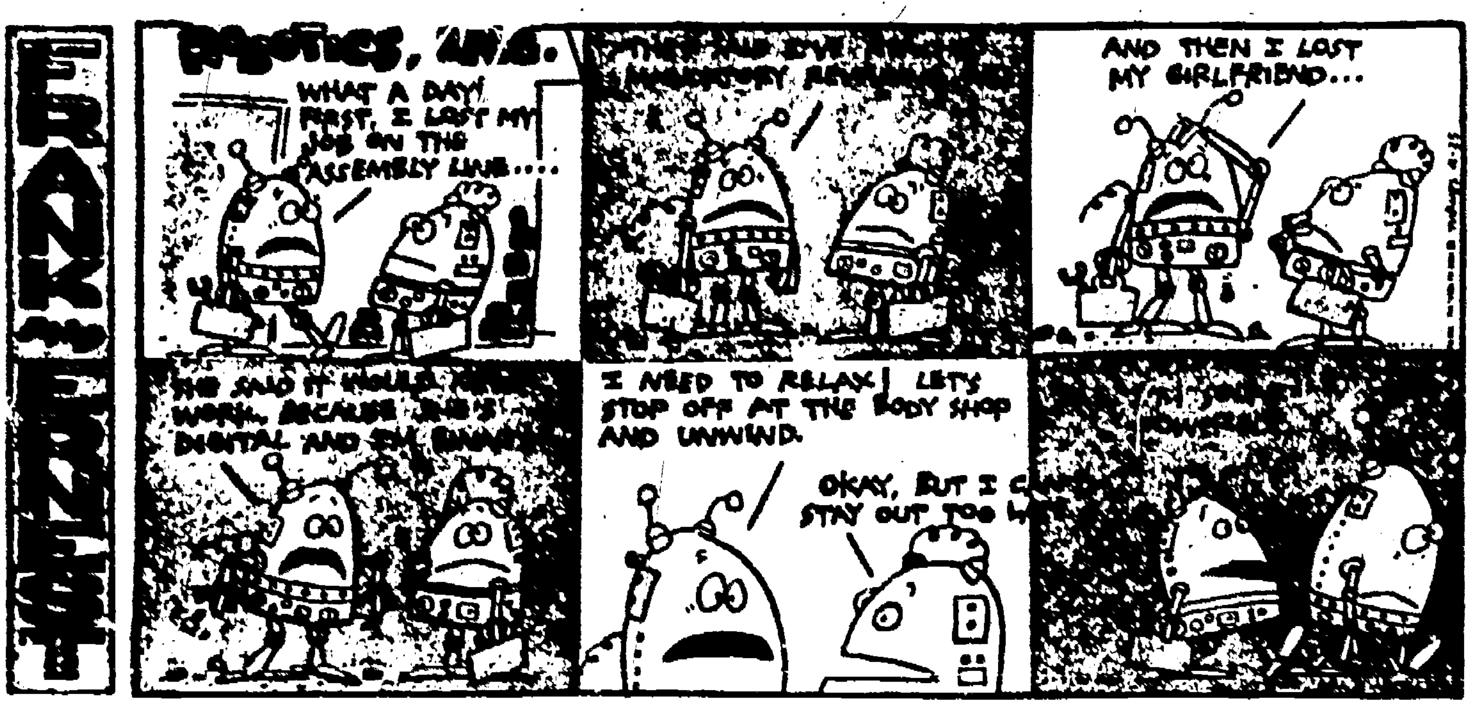
The influx of huge companies into the robot industry has significance far beyond the competitive challenge it poses to established robotmakers...Perhaps most important, the major sales effort these corporate heavyweights will mount should help increase robot use in the US and narrow Japan's lead in placing robots in factories. Increased robot use should also help make US firms more effective competitors in international markets...

"Our record of 4,000 robots in 20 years is a rotten record. Japan in half the time has installed 16,000," admits John J. DiPonio, a Ford Motor Company executive who serves as president of the robotics arm of the Society of Manufacturing Engineers...

Mr. Diponio worries that Japan's greater use of robots will cut the costs of that nation's companies significantly, increasing their ability to compete in international markets. For example, Unimation figures a $50,000 robot costs General Motors Corporation about $6 an hour to operate against the $19-an-hour cost for human labor. Thus, in general, the more robots US industry installs, the lower its production costs would be. (*Christian Science Monitor*, page 11; March 5, 1982)

Robot Industry in Japan

According to 1982 figures of the Robot Institute of America, in the summer of that year there were 14,246



programmable robots on the job in Japan. This represented 59% of those in use worldwide. Japanese firms churned out more than $210 million worth of robots in 1980, and industry analysts predict the figure may hit $1 billion by 1985.

Not only are the Japanese installing robots on a massive scale, they are also becoming a world leader in the design of innovative robots. This has led to a growing concern amongst other industrial nations, especially the United States.

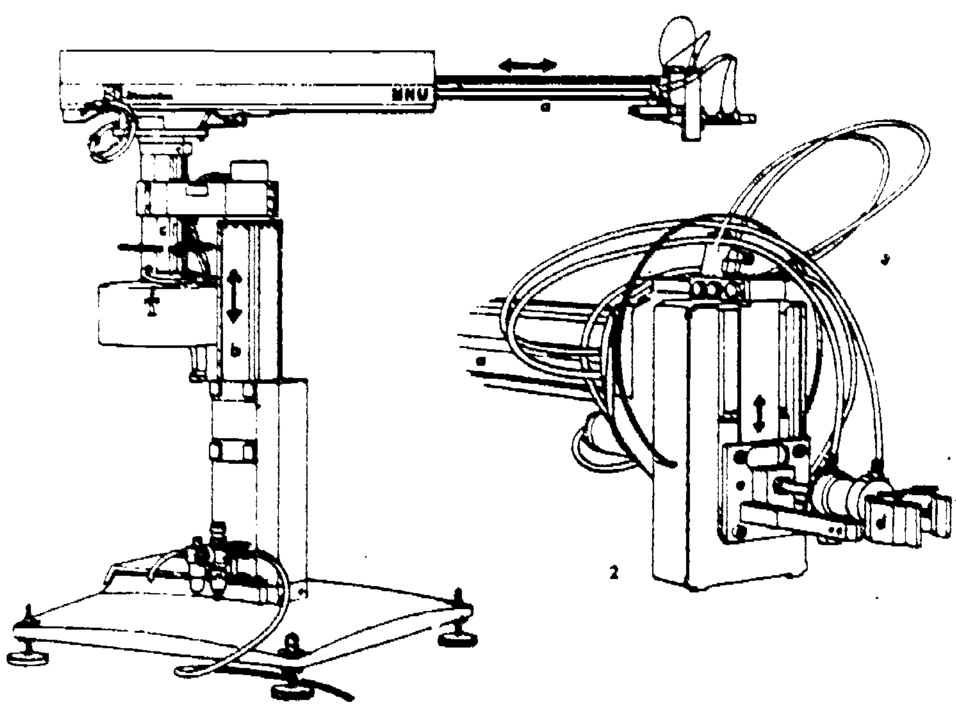
In a *Newsweek* article, August 9, 1932, some of these Japanese innovations were described.

> Today's robots are mostly mechanical arms directed by a microcomputer that can be rapidly reprogrammed to do a variety of tasks. They have become so self-suffi:ient that several companies have started up "ghost shifts"--lines that can work at least one shift a day with little or no human supervision. Near the base of Mount Fuji, for instance, Fujitsu Fanuc, Ltd., has built a toolmaking factory that requires only one

worker to keep a nightlong vigil over 10 robots and assorted other machines...

For the moment...the Japanese are setting the pace. Last fall, Kawasaki Heavy Industries Ltd., Fujitsu Fanuc and Nippon Electric Co. came up with the first generation of robots capable of assembling auto parts or electric motors....Nachi-Fujikoshi Corp. may soon start marketing robots that can locate welding spots with their own "eyes," and Ichiro Kato of Waseda University has developed a 25-fingered cancer-detecting robot that can report the location and hardness of a breast tumor. Kato has also created a high-precision robot arm that can open a door and a pair of legs that can duplicate the human walking motion, while Fujitsu Fanuc says that by 1984 it will introduce an "intelligent" robot that can see and feel.

Much current research, spurred on by competition between the U.S. and Japan, is on artificial intelligence and automated engineering.



This pneumatically powered industrial robot (1) with six freedom degrees is manufactured by Electrolux in Sweden and is able to move an object to any point within its working area. The robot arm (a) can be moved to and fro horizontally and is mounted on a pillar (b), by means of which it can be raised and lowered. The arm can also rotate round its shaft (c). The grab device (2) has two fingers (d), which can be moved against, and away from, each other and are mounted on a plate (e), which can be moved vertically. The whole grab device can also be rotated round the robot arm.

A Robot Visits Alaska: *Hero I* Competes with the Iditarod

In March of 1983, Bob, one of the authors of this course, attended a conference. He came back with an intriguing story.

When I arrived at the hotel I first had to shake off the culture-shock of the hustle and bustle of the big city. After setting up my solar greenhouse display, I decided to wander around the exhibit hall.

In the hallway I came face to face with a robot! *Hero I* was visiting Alaska, to demonstrate how an eductional robot works in the classroom.

First thought--oh no! Now *I* am being replaced! A gasp of relief let go from my tense chest as I was quickly told that, no, no, no, Hero was *not* a teacher, but a teacher's aide.

Well, seeing the threat removed, I decided to not demolish Hero on the spot.

The following day I was torn between attending Hero's demonstration and watching the beginning of the Iditarod. I decided on a compromise. After watching the first few glorious dog-teams pulling sturdy-looking sleds and sledders, I rushed back to the hotel, wondering who the real heros are.

When I arrived, *Hero I* was about to go through his routines. With the cold air still in my lungs, and images still before my eye of frisky dogs running briskly in the snow...I slunk down in a chair.

Hero proved to be quite personable, like a precocious child

Robot toddles to the Hill to plead for more R&D

Washington

"Meet a constituent," said Sen. Donald Riegle Jr. (D) of Michigan, introducing Hero 1, a one-armed robot. Hero asked a Senate subcommittee in its electronic monotone Thursday to finance industrial research and showed off a bit by singing a verse of "Happy Birthday."

"Does he vote?" Sen. Frank Lautenberg (D) of New Jersey asked as subcommittee members clustered around Hero to accept a copy of testimony it offered in its extended arm.

Hero is a Riegle constituent since it was produced by a Benton Harbor, Mich., company. Senators said it was the first time a robot used its own voice to testify before Congress.

who has amassed enormous knowledge and capabilities, but remaining innocent of deep understanding and definitely not very independent.

Hero actually is an extremely sophisticated robot, designed for classroom use to help teach students about robots. Here is a list of Hero's talents and specifications:

1) Arm moves in five separate ways, and head rotates 350 degrees.

2) Front-wheel drive mechanism provides accurate motion of entire robot.

3) The internal microprocessor is easily communicated with by external student-designed or other circuitry.

4) Voice synthesizer allows the robot to talk in unlimited vocabulary and to produce various other sound effects.

5) Ultrasonic motion detector senses the slightest motion around the robot.

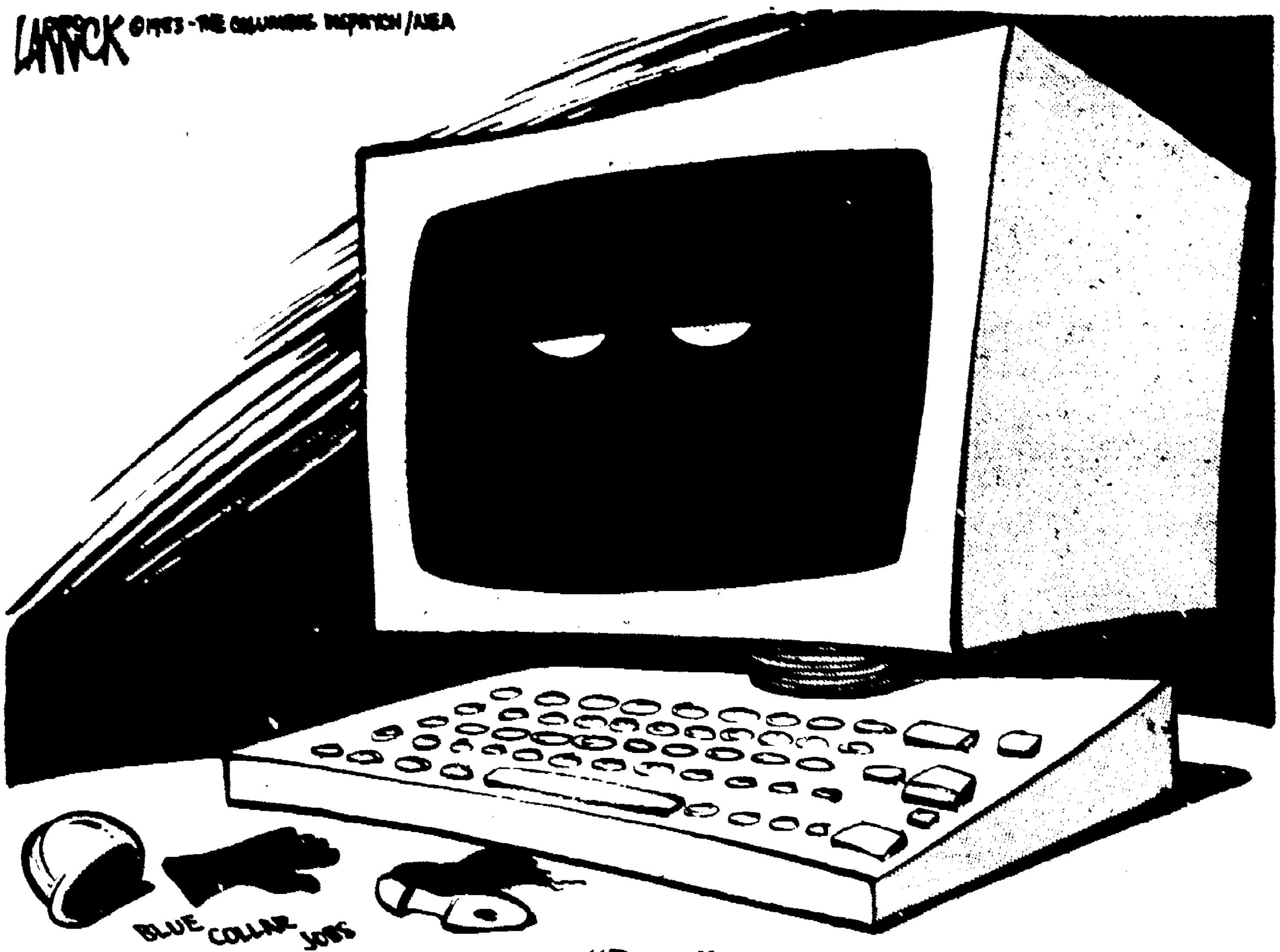
6) Sound detector senses and can determine the loudness of a wide range of sound frequencies.

7) Light detector measures 256 intensities of visible light.

8) Console with keys allows for simple manual programming.

9) Cassette interface allows for input of sophisticated programming.

10) An internal clock/calendar can be used to program Hero to "wake up" and do a task at anytime within 4 years (the perfect murder weapon!).



"Burp."

11) A remote control device provides a quick and easy way to program complex movements of the arm and body. This means that Hero is a fast and accurate learner!

A New Revolution in the Making: You are part of it.

We have discussed technological revolutions at great length in this chapter. We learned that agriculture led to the development of urban life, that printing made mass communication possible, and that the Industrial Revolution brought societal changes which we are still in the midst of.

Automation and new communications technologies--computers, robots, radio, television, and communication satellites--are shaping a new world. Our age is frequently called the Information Age because all of these technologies are used to process information.

If you were to walk into a government office in Juneau today you would see word-processors where a few years ago there were typewriters, and computers steadily replacing filing cabinets.

The state legislature has teleconferencing networks which use satellites to send and receive messages to and from almost all regions of the state. Alaska is a leading innovator in telecommunication--in the United States and in the world. Alaskan citizens can participate in the law-making process by testifying while laws are being made.

Our state transcends time. While being at the leading edge of the technological frontier, we also have some of the last remaining wilderness frontier. Of the world's hunting and gathering heritage--the pre-agricultural stage of human history--we perhaps have some of the most extensive traditional "subsistence" cultures.

MALEMUT FAMILY FROM SHAKTOLIK

Where does this put us, and where are we going? In a later lesson we take a closer look at the history of technology in Alaska. In a later chapter we will ponder the very real possibility of self-replicating, automated industrial systems, some of which are being planned for operation in remote wilderness area--such as can be found in Alaska.

COMPLETE THE FOLLOWING WORKSHEET.

Toshio Sakai

Mechanized death

Robot stabs Japanese factory worker

TOKYO (AP) — A 37-year-old factory maintenance worker was stabbed to death by a robot that suddenly started up and pinned him against another machine, a government report said today.

It was the first recorded fatality blamed on one of the approximately 70,000 robots in use in Japanes industrial plants.

The accident occurred at the Kawasaki Heavy Industries in Tokyo last July, but it was kept secret until today, after the investigation was completed.

The investigators said the victim, Kenji Urada, stepped across a safety barrier and inadvertently triggered the robot, whose arm stabbed him in the back.

The report concluded that Urada was guilty of carelessness but said safety measures in the plant were inadequate, according to Hiroshi Goto, chief of the local labor standards bureau.

A HISTORY OF TECHNOLOGY

WORKSHEET

1) Use the following outline to write a summary of this lesson.

1) history of automation

2) mechanical computer

3) electronic computer

4) semi-conductor technology

transistor

integrated circuit

microprocessor

5) robots

6) U.S. robot industry

7) Japanese robot industry

8) automation in Alaska

Two and a half pages are provided here.
Use your own paper if you need more room.

2) What are your career plans, and how do you think the newly-developing automation technologies might affect those plans?

3) Let's go back for a moment to the first lesson of this course, and recall some of what E.F. Schumacher had to say.

> To Schumacher, work is of spiritual importance, an opportunity for people to develop spiritually. Human labor is not *only* for the purpose of producing goods and services. Schumacher noted that most modern economists consider "work as little more than a necessary evil." To the employer, work is "simply an item of cost, to be reduced to a minimum if it cannot be eliminated altogether, say, by automation."

What importance do *you* place on work, and what do *you* feel is the appropriate place for automation in human society?

4) The development of machines which can learn and think is already taking place. It is projected by many scientists and engineers--as well as science-fiction writers--that machines could eventually become "new species." At first these new "organisms" would be similar to domesticated animals--controlled by humans. Eventually they could become independent.

Do you feel that the above projections could really come true? Why or why not?

5) As automation technologies become more advanced, in what ways would you expect human society to change?

6) Let's consider the possibility that independent machines (robots) could become better scientist and engineers than humans--unless we use genetic engineering to make "smarter people."

Now let's assume that the robots have decided to compete with the humans. Should the humans use genetic engineering to "manufacture" new and "better" people who are able to compete with the robots?! [This question might seem like a joke- but the situation presented is *not* at all impossible.]

7) Describe a wilderness scene in Alaska. Then describe the arrival of an automated, self-replicating industrial system. What happens during the next 10 years?! [You might want to describe the reaction--and actions--of people who live in the area!]

A HISTORY OF TECHNOLOGY

LESSON 11

"Your journey symbolizes Japan's growing position in world affairs. We meet in Anchorage, Alaska, a place which is approximately the same distance between Tokyo and Washington, D.C. and this fact reminds us that for the past quarter century that we have built a structure of political, economic and cultural ties which spans the space between our two countries, and may this historic meeting, the first meeting in history between the Emperor of Japan and the President of the United States, demonstrate for all the years to come a determination of our two great peoples to work together in friendship for peace and prosperity for the Pacific and for all people in the world."

President Richard M. Nixon, September 26, 1971

A HISTORY OF TECHNOLOGY

LESSON 11

THE DEVELOPMENT OF TECHNOLOGY IN ALASKA

> *...Alaskans can no longer be content to import 98 per cent of their red-meat supplies and depend on a transportation and distribution system that at times maintains only a four-day supply of food within the State.*
>
> *One of the most unanimous and consistent philosophies supported by Alaskan voters and elected officials is that non-renewable-resource wealth must be used to develop renewable-resource industries.*
>
> **Alaska Agricultural Action Council**
> *1982 Annual Report*

INTRODUCTION

Alaska was one of the most remote and sparsely settled regions of the world until the Japanese invaded the Aleutian Islands about 40 years ago. At that time the world was engulfed in the most extensive war ever experienced in human history--World War II. Its predecessor, World War I, was erroneously dubbed "the war to end all wars" and took place mostly in Europe. World War II raged in Europe, Africa, Asia--and finally reached the frontiers of North America when the Japanese bombed Dutch Harbor and occupied Attu, Adak, and Kiska Islands in Alaska.

Suddenly, virtually overnight, men and machines poured into Alaska to push the Japanese back into the sea--which was accomplished the following year.

The technological accomplishments of the American military campaign in Alaska were astonishing. The army punched a road through to the lower 48 in about nine months. This road is now called the Alcan, or Alaska Highway. Air bases were constructed at breath-taking rates.

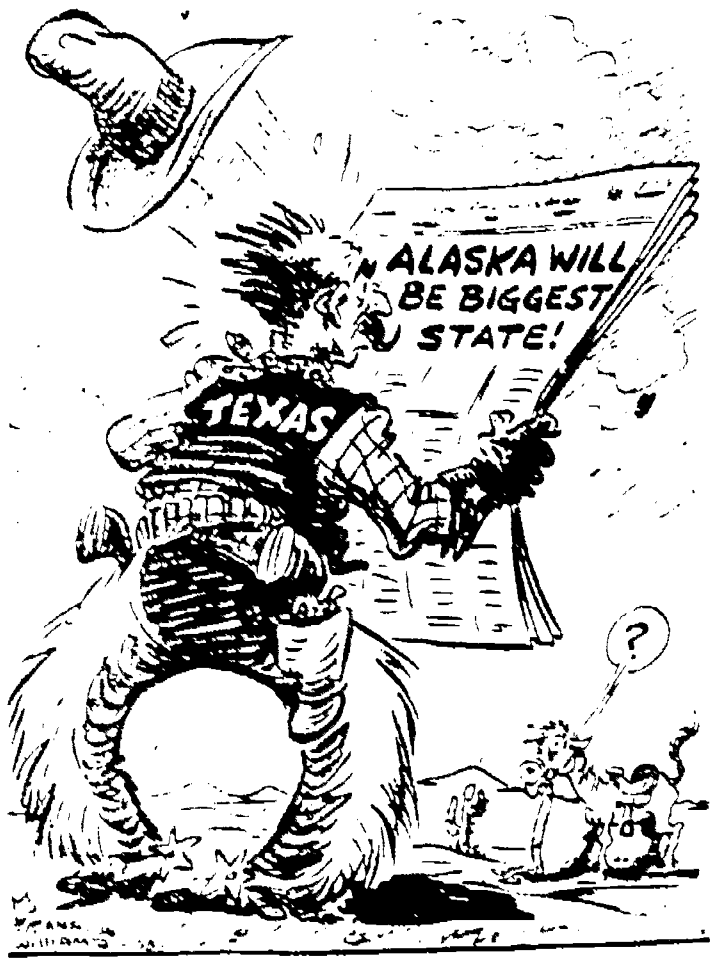
Alaska had entered the modern technological world, and since that time there has been very little looking back.

The written history of Alaska prior to World War II is very sketchy. But what has been written begins about 1741, the year in which Vitus Bering and his crew discovered a small portion of this vast territory. Before this time, Alaska was virtually unknown to the rest of the world.

After Alaska was discovered, its colonial governments were mostly interested in the extraction of its resources. There was little interest in settling or developing the region.

It was not until 1959, when statehood was granted, that Alaska became self-governing. Alaska had for a long time been controlled by governments which were located thousands of miles away. With statehood, Alaskans gained more power to influence the direction and extent of their own development.

With development has come a growing population. In 1940, just prior to World War II, the population of Alaska was 72,524. By 1960, the population had tripled to 226,167. In 1983, there were 440,000 people.



SHOOTIN' WORDS!

Statistics illustrate changes since statehood

The figures below, supplied by the Library of Congress, illustrate some of the changes in Alaska over the past quarter century since achieving statehood.

	1958	1983
State Population	213,000	422,187
Juneau	(approx.) 6,000	22,680
Fairbanks	(approx) 11,400	53,983
Anchorage	(approx.) 82,800	204,216
Agriculture	$5,563,000	$9,660,000
Banks' Assets	$173,000,000	$2,782,000,000
Insurance Premiums	$30,000,000	$478,600,000
Timber Board Feet	285,352,000	445,823,000
Fishing Pounds	371,117,000	984,000,000
Radio Stations	18	52
Television Stations	5	12
Newspapers and Periodicals	6	73
Government Employees	21,000	55,000
Defense Expenditures	$289,000,000	$984,886,000
Marriages	1,763	(approx.) 5,000
Divorces	679	(approx.) 3,500

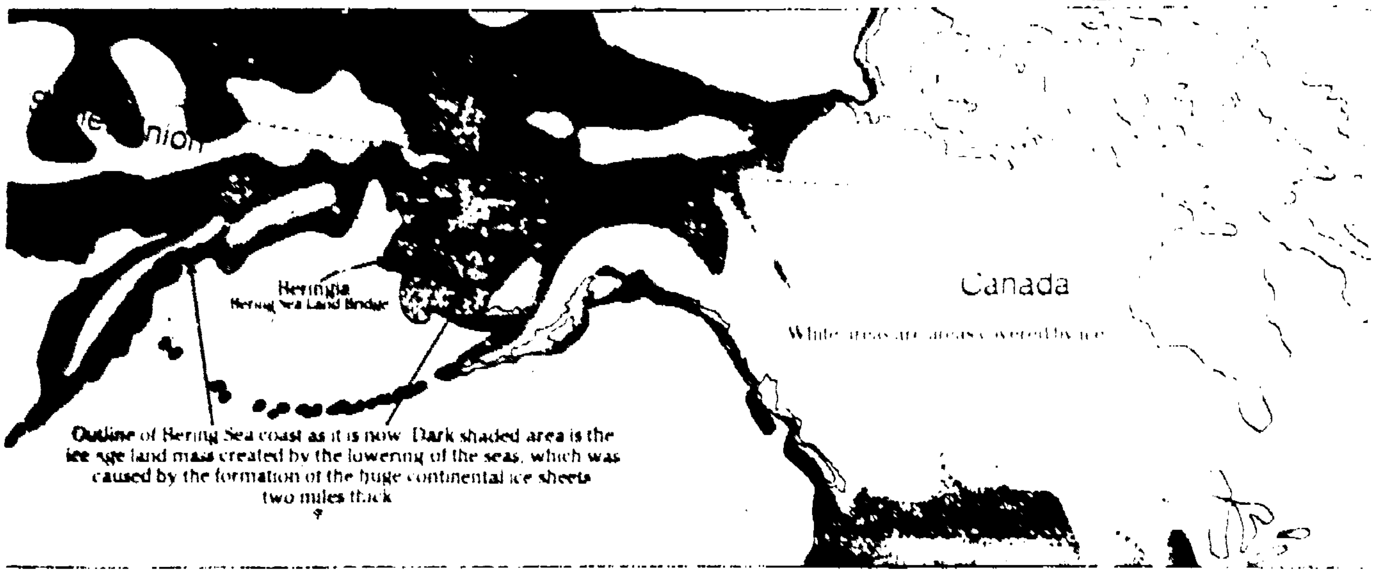
THE FIRST ALASKANS

For thousands of years the native people of Alaska lived in almost total isolation from the rest of the world. They developed technologies which enabled them to adapt to various environments.

The first humans probably arrived in the Bering Sea area of Alaska about 10,000 years ago. These early hunters crossed a land bridge which connected northwestern Alaska to northeastern Siberia.

It is estimated that there were about 75,000 native people in Alaska when Vitus Bering arrived. There were--and still are--six major cultural groups: Eskimo, Aleut, Athabascan, Tlingit, Haida, and Tsimshian. The following description of their technologies is very brief and

The Ancient Bridge



incomplete. Hopefully, you have studied these cultures in more detail in other courses.

The Eskimos

There are three major Eskimo groups: the Pacific Eskimos, the Bering Sea Eskimos (Yupik), and the Arctic Eskimos (Inuit). Each of these groups had a distinct pattern of survival.

The Pacific Eskimo numbered about 8700 people when the Russians first came to Alaska. There were about 9000 Yupiks and 6350 Inuits.

The Pacific Eskimos lived on Kodiak Island, on the Alaskan Peninsula, and in the Prince William Sound area. They hunted marine mammals and birds, and fished for salmon in the streams.

The Yupiks were sustained by the wildlife of the sea and rivers, and the caribou on land.

The Inuits distinguished themselves by hunting for whales from their large skin boats called umiaks. Because of the scarcity of food, there were only

two persons per 100 square kilometers in the northern region where the Inuits lived.

Eskimo people are famous for their ingenious technological innovations. These include: kayaks, parkas, waterproof skin clothing, and snow goggles. Some of these inventions were adopted by Western cultures.

BUREAU OF AMERICAN ETHNOLOGY EIGHTEENTH ANNUAL REPORT PL. XXVI

WOMEN AND CHILDREN OF CAPE SMITH

The Aleuts

When the Russians reached the Aleutian Islands in the 1740's, there were about 18,000 Aleuts. Practically every island was inhabited.

The climate and physical geography of the Aleutian Islands is unlike that of other regions of Alaska. Rainfall is heavy, and violent wind called "williwaws" often sweep over the treeless landscape. However, the temperature rarely ever falls below 25 degrees Fahrenheit.

According to early Western observers, the typical house was large and built underground. Often many families would live in one house. Large villages had as many as seven such houses. These were the permanent settlements and were usually located on the Bering Sea side of the islands because of an abundance of fish and a larger supply of driftwood found there.

Aleut women and children gathered berries, edible greens, and other herbs. Aleut baskets made of finely-split

Aleuts in Baidarkas

grasses are some of the finest baskets in the world.

Foxes and other small animals were trapped, but there were no large mammals on the islands. Because of limited meat protein available on the land, the Aleuts became masters at hunting marine mammals. They were among the best of the North American native hunters.

The Aleuts used spears and harpoons to kill seals, sea otters, sea lions, walrus, and sea cows. These skilled boatmen propelled their skin-covered kayaks with a double-bladed paddle in the often stormy and fog-shrouded waters.

The Athabascans

The Athabascan Indians were spread over a wide area of Alaska at the time of the first contact with white people. Today there are twelve distinct groups: the Koyukon, Kutchin, Han, Tanacross, Tanana, Upper Tanana, Ahtna, Tanaina, Upper Kuskokwim, Holikachuk, Ingalik, and Eyak.

Athabascans had to acquire a great deal of flexibility to survive, because of the severity of climate and the frequent scarcity of game in the areas in which they lived. They hunted caribou, moose, and bear with bow and arrow. They also took caribou and fur-bearing mammals with snares and used deadfall traps on bears. These devices are similar to the automated traps which you read about in an earlier lesson. Fish provided an important source of food for the people in the Yukon Valley and along Cook Inlet.

Surviving the winters posed many problems for the Athabaskans. They developed snowshoes to stalk game over the snow, and often fished through holes in the ice.

Fishing on the Yukon

The Tlingit, the Haida, and the Tsimshian

In Southeast Alaska the Tlingit, the Haida, and the Tsimshian people had developed an advanced culture based on the use of the sea and the forest. There were about 10,000 Tlingits and 8,000 Haidas at the time of Russian contact. The Tsimshians of Annette Island moved from Canada in 1887. These three tribes shared a fairly similar culture.

The sea was their primary source of food, providing salmon, cod, herring, candlefish, mollusks, seal, sea otter, and sea lion. Deer and bear were plentiful in the forests.

The native people of Southeast Alaska enjoyed a moderate climate and an abundance of food. Consequently, there was ample time for activities other than

providing necessities. Wood crafts were developed to a fine art. Large canoes which could withstand huge sea waves were carved from cedar trees. The Haidas of the Queen Charlotte Islands built canoes which were 50 feet long and 8 feet wide.

The Southeast Indians built large frame houses which were covered with hand-split cedar or spruce planks. These were expertly constructed and often elaborately decorated with beautiful symbolic paintings. The women wove intricate baskets from spruce roots and cedar bark. The weaving of cloth was also highly developed. One especially valued trade item was the Chilkat blanket, which was woven from mountain goat wool. Garments were also made of woven cedar bark.

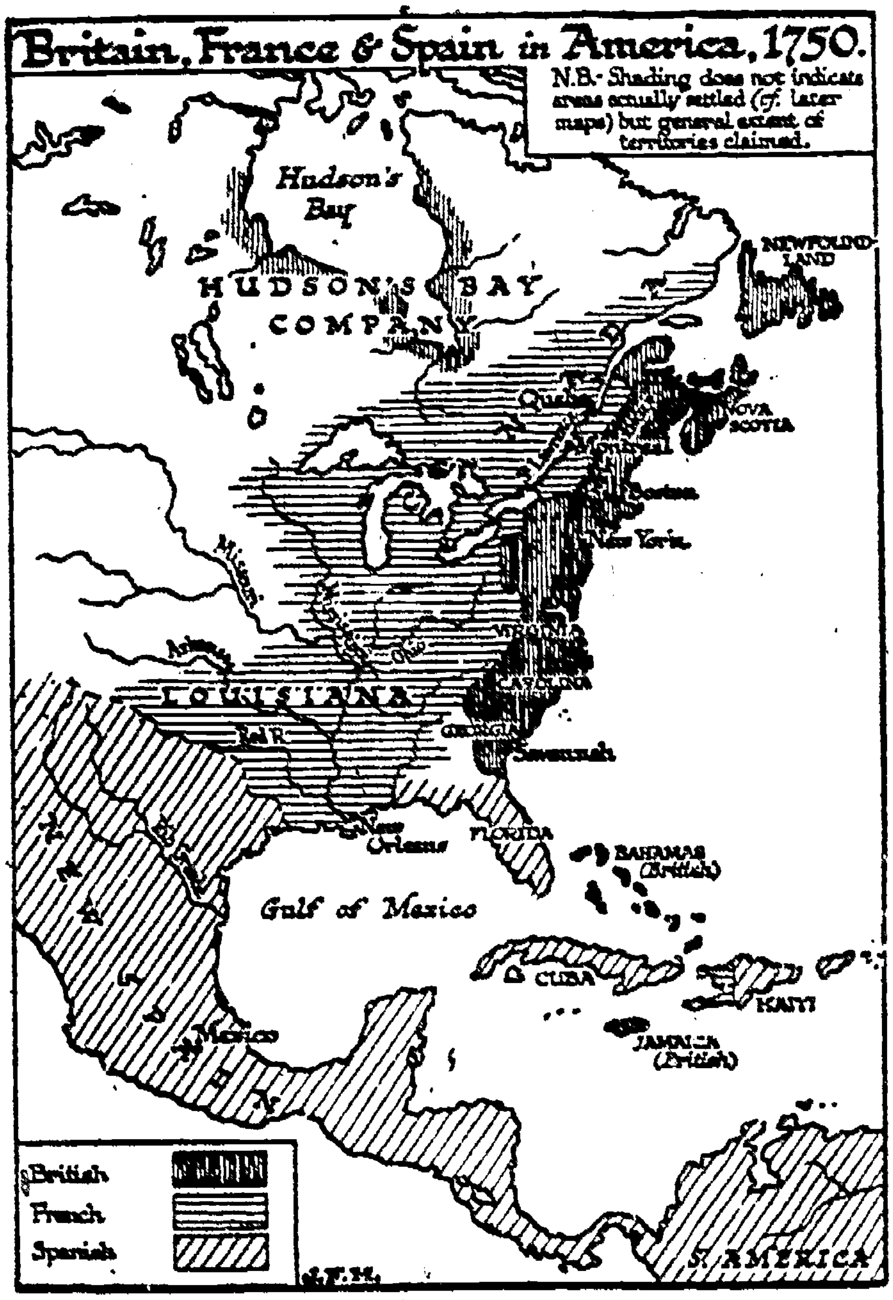
Chilkat woman weaving a dance blanket

DISCOVERY OF THE LAST FRONTIER

In the 18th century while the English, French, and Spanish were moving westward across and around the North and South American continents, the Russians were moving eastward across Asia--primarily in search of fur. When the supply of fur-bearing animals in one region became diminished, the Russian hunter-trader moved to a new region. They eventually reached the eastern coast of Siberia and were forced to make the big plunge across the frigid Arctic waters to Alaska.

The first European explorers reached Alaska a little later than the Russians. However, the Russians established the first and most enduring colonies in the newly discovered territory.

Russian and European explorers were from technologically advanced cultures which had already entered the Industrial Revolution. Because of this, they had a



substantial advantage over Alaskan native people--who were in the hunting and gathering stage of technological development. Even though these first explorers were few in numbers, their large ships, cannons, and muskets allowed them to subdue the native people.

You might recall from an earlier lesson that increased exploration and trade had resulted in an economic boom for Europeans. This boom had helped to deplete European forests...which led to

the mining of coal...which called for the need of horse-powered water-pumps to pump water from the mines...which were replaced by steam-powered pumps...which "started" the Industrial Revolution in 1702 with Sayery's steam engine. Vitus Bering's arrival in Alaska 39 years later was part of the massive expansion of Western Civilization.

The Fur Trade: First Large Export Industry in Alaska

One of the primary reasons that the Russians came to Alaska was to search for fur-bearing animals. There was a great deal of money to be made by selling furs. Until the discovery of gold, in 1880, the fur trade was one of the most important industries in Alaska.

> **FUR**
>
> In 1979, the fur trade was worth five and a half million dollars to Alaskans.

The Russians recognized the boating and hunting talents of the Aleuts. The fur traders enslaved the Aleut men and forced them to hunt sea otters and seals. The Russians sometimes held the wives and children of the hunters as hostages.

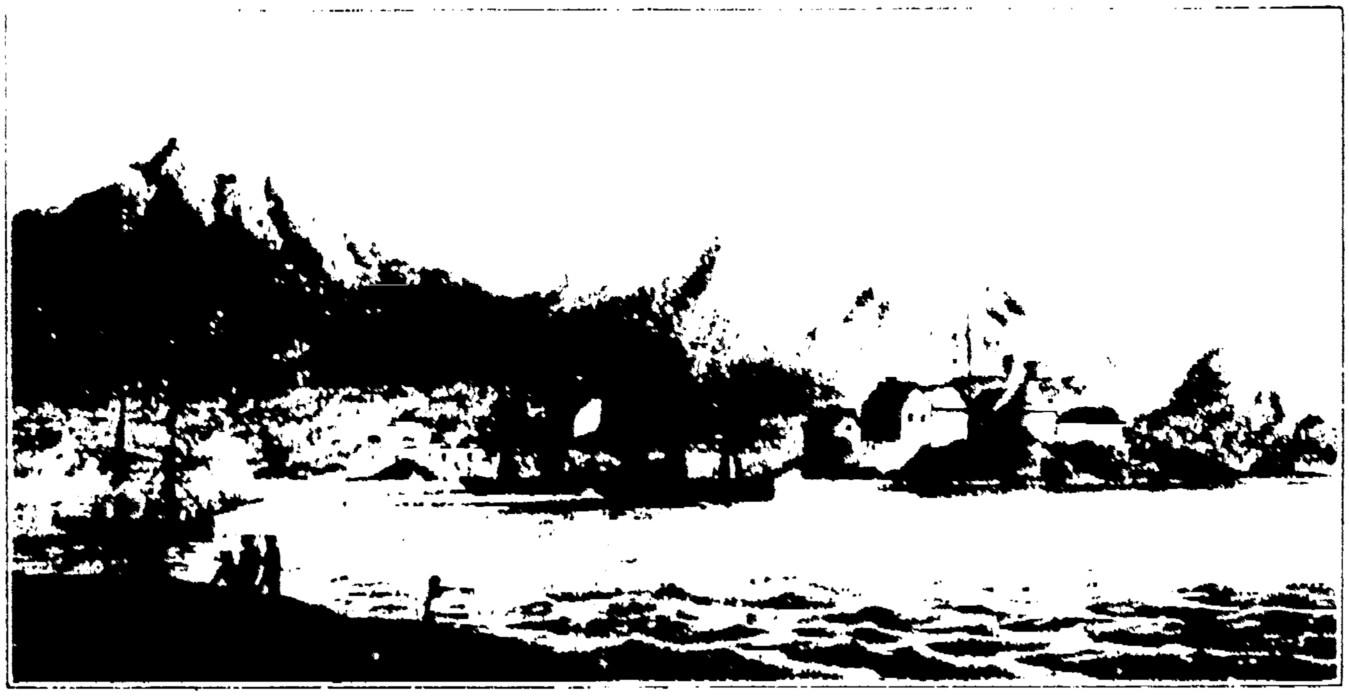
Kodiak was established in 1784 by a group of fur traders led by Gregory Shelikov, who was granted a ***monopoly*** for fur trading by the Russian government. A monopoly is a business that has no competition from other businesses.

GRIGORII IVANOVICH SHELIKOF
First organizer of the fur trade in Alaska under Russian rule

The Kodiak settlement led to the establishment of the Russian American Company, which governed Alaska for 64 years. The first manager of this company was Alexander Baranoff, who ruled as governor of Alaska for 19 years. During this time, he expanded

the company's territory to Southeast Alaska, where he subdued the Tlingits and established the Russian capital at New Archangel, which is currently called Sitka.

The Sitka colony prospered, which created a demand for logs and lumber for construction. Firewood was used to heat buildings and charcoal was made for the metal working foundries.



SITKA IN 1805
This is the first picture ever made of Sitka
From Lisianski's Voyage

At first lumber was hewn or sawn by hand, but water-powered saw mills began to appear. Probably the first water-powered sawmill in Alaska was built at Redoubt Bay near Sitka, in 1833. In 1853 this mill was converted to steampower.

Shipbuilding was an important occupation in the early days of Sitka. For a long time Sitka had the only shipbuilding facility on the Pacific coast of America.

TIMBER

The timber industry continues to be important in Alaska. Logging, pulp mills, and sawmills employed 3,426 workers in 1977, with a product valued at approximately $225 million. Since 1903, about 300,000 acres of coastal forest have been harvested, which is less than 5% of the potential commercial stands.

Alaska Ice Company: Industrial Infrastructure

Infrastructure is a word which you will encounter later in this lesson and in the second part of this course. *The American Heritage Dictionary* offers the following definition:

> 1. An underlying base or supporting structure. 2. The basic facilities, equipment, services, and installations needed for the growth and functioning of a country, community, or organization. 3. A governmental or administrative apparatus.

The development of technologies and industries helps to establish an infrastructure which is necessary for further development. The sawmills, foundries, and shipbuilding yards in Sitka provided a solid infrastructure for development.

The Alaska Ice Company brought further changes to Alaska's industrial infrastructure. The company was established in 1850, to take ice from Alaska to California. This industry was a joint venture which included the Russian government and a group of American investors.

Few people today have heard about this ice-exporting venture, but historically the spinoffs were: the

introduction of horses into Alaska, the first oats planted, the first roads, and the first iron rails. These were important developments for the growing infrastructure in Alaska.

AGRICULTURE

Oats and horses have not remained economically important in Alaska, but an agriculture has continued to develop. In 1977, 19,268 acres were planted--about 30 square miles of the state's total of 600,000 square miles. An estimated 210 farms produced crops valued at $9.8 million.

In more recent times, there has been a substantial effort to develop an agricultural infrastructure in Alaska. In 1978, 60,000 acres of land were sold by the state for the development of a grain industry. In 1982, 24,227 additional acres were sold. The state government has also been helping with the development of grain-transportation, grain-storage, and livestock-processing facilities.

The United States Buys Alaska

> When American people get hold of a country there is something about them which quickens, vitalizes and energizes it....Let American enterprise go there, and as if by electricity all that country will waken into life and possess value.
>
> --Senator Charles Sumner
> of Massachusetts
> April 9, 1867

The above quote showed an optimism for the future of America's newest territiory at the time it was purchased. But the early years of the U.S. administration of Alaska are characterized as one of indifference and

neglect. This was due to ignorance on the part of most government officials as to the true nature of the climate, geography, and natural resources of Alaska. Many people felt that the U.S. government was cheated when they purchased Alaska from the Russians in 1867. According to a government document which was edited by Ernest Gruening:

> The minority report of the House Committee on Foreign Relations had...made a sweepingly unfavorable report based on its "conclusion that the possession of [Alaska] is of no value...to the United States...that it will be a source of weakness instead of power, and a constant annual expense for which there will be no adequate return...no capacity as an agricultural country...no value as a mineral country...its timber...generally of poor quality and growing upon inaccessible mountains...its fur trade...of insignificant value and will speedily come to an end...the fisheries of doubtful value" and finally, "that the right to govern a nation...of savages in a climate unfit for the habitation of civilized men was not worthy of purchase." (quoted from *The State of Alaska*, pages 27 and 28)

Statue of Ernest Gruening in the Hall of Fame in Washington D.C. Each state can have two statues in the Hall of Fame. For Alaska, it is this one of Gruening and Bob Bartlet.

By 1885, less than twenty years after the U.S. paid Russia $7.2 million for the territory, Alaska had contributed more than $30 million to America's national wealth. In that same year, Washington spent $25,000 on education in Alaska.

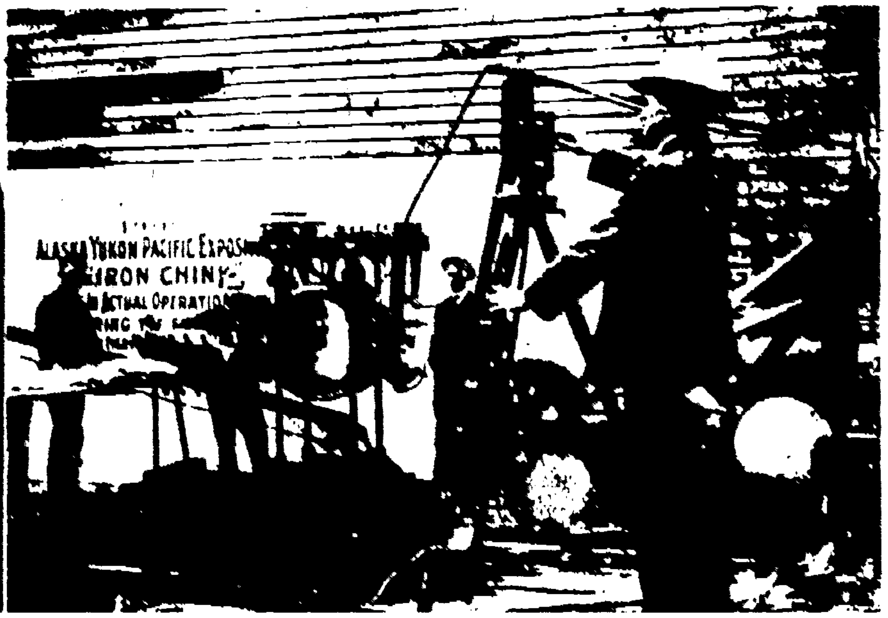
More Monopolies

The U.S. government followed in the footsteps of the Russians by granting commercial monopolies to a few large

companies--to develop Alaskan resources. For ninety years these businesses were controlled by distant owners who were granted a free hand in the fur trade, in fisheries, and in the lumber and mining industries.

One of these monopolies was granted to the Alaska Commercial Company. This enterprise and its successors hunted seals and sea otter almost to extinction. In 1911 these animals came under protection of the federal government. Meanwhile, New England whalers hunted whales and walruses until their numbers had decreased to the point where the food supply for Eskimo villages was threatened.

E. A. "IRON CHINK" SMITH the inventor of the fish cleaning machine that made possible large scale salmon canning. By trade a cook, by nature a humorist, Smith had mechanical ability which led to his devising "an apparatus to do away with Chinamen." (Courtesy Smith Canning Machines.)



IRON CHINK ON STAGE -- Moving picture debut of the mechanical marvel that put salmon canneries on a production basis. Invented by F. A. Smith, this early model was exhibited at Seattle's A.Y.P. Exposition in 1909. (Courtesy Smith Canning Machines.)

The fisheries were the next to be developed, with the numbers of canneries climbing from 37 in 1888 to 135 in 1918. The 1889 catch was 700,000 cases of canned salmon worth almost $3 million. As the fish made their runs upstream to spawn each year, barricades were erected on the rivers and most of the salmon were netted. Since few fish were allowed to spawn, whole runs were fished out.

BRAILING A SALMON TRAP IN ALASKA

The depletion of the food resources caused the federal government, religious groups, and other interested individuals to take positive action to relieve the plight of many native people--many of whom were starving to death. One of these actions was to import reindeer and Lapp herders from Scandinavia (northwestern Europe) to alleviate the suffering of some of the Eskimo people.

Ernest Gruening called this action "the most important single contribution made to the natives--or at least part of them--in the first half-century of the United States rule..."

FISH

Alaska's current commercial fish production is greater than that of any other state in terms of value, and second in terms of weight. In 1980, the U.S. commercial catch of fish and shellfish in Alaska totaled 1.1 billion pounds and was valued at $556 million. At the same time, foreign fishing operations in the States's 200-mile offshore zone took 3.3 billion pounds of bottom fish, worth about $288 million.

Mining and Changes in the Population

It was the lure of gold that first brought people in any great numbers to Alaska. Between the years 1890 and 1900, just after gold was discovered, the population of Alaska almost doubled--from 32,052 to 63,592. The U.S. census just prior to this time had showed a slight decline in population. In 1880 there were 33,426 people, compared to 32,052 in 1890.

Another important population trend to consider is that of natives compared to non-natives. In 1900, for the first time, the non-natives outnumbered the natives-- 30,450 compared to 29,542. You might also notice that by 1900 there were about *half* as many natives in Alaska as when the Russians first arrived 150 years earlier.

While the native population of Alaska has not appreciably increased since the early 1900's, the non-native population has skyrocketed.

The discovery of gold was responsible for the settling of Juneau in 1880. Skagway became the major port for the Klondike gold strike. The modern cities of Nome and Fairbanks also had their beginnings about this time, as a direct result of the quest for gold. The federal government began to survey the land, and set up new agencies to administer the growing population.

MINERALS

In addition to gold, other minerals have become commercially important in Alaska. Almost $2.9 million was received for gold mined in 1977. In that same year, approximately $23 million was received for barium, bituminous coal, gemstones, lead, silver, copper, mercury, natural gas liquids, platinum, and tin.

There are huge reserves of natural gas and coal in Alaska. Natural gas, in 1983, provided much of the energy used in the Anchorage area. Coal was being used to generate electricity in the Fairbanks area. Both of these resources will likely figure prominently in Alaska's future--both for use within the state and as exports.

Alaska has the potential of becoming a major exporter of minerals.

The Military Boom

The first extensive transportation infrastructure in Alaska was developed by the U.S. government for military purposes. Construction began in 1915 on the first public railroad, which eventually connected Seward and Fairbanks. The purpose of the railroad was to open up the coalfields of the interior for the U.S. Navy's Pacific Fleet. The city of Anchorage had its start as one of the construction camps along the new railroad. The Alaska Railroad is still owned by the federal government, though there has been talk of other ownership arrangements.

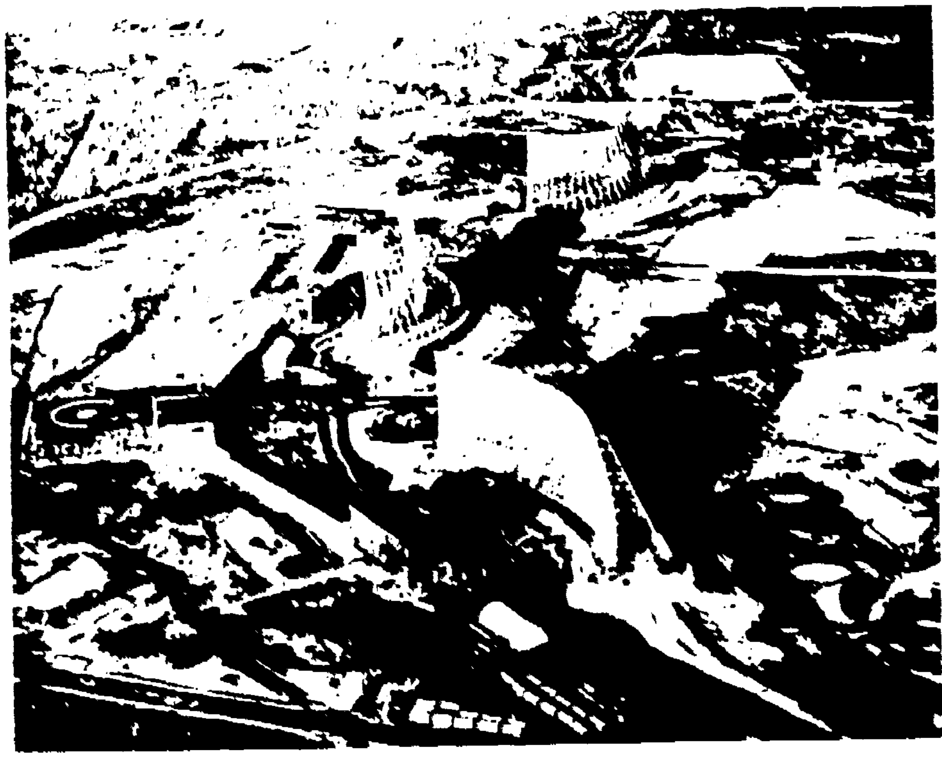
The Alaska (Alcan) Highway connected the continental United States to Alaska by road for the first time on November 20, 1942. The road was built to connect military bases along the air

route to Alaska--between Great Falls, Montana and Ladd Airfield in Fairbanks. It took seven military engineering regiments and forty-seven civilian contractors exactly nine months and six days to complete the road.

After the Japanese invaded the Aleutian Islands during World War II, the federal government spent massive amounts of money on military defense projects in Alaska. Several naval and air bases were built.

During the tension between the United States and Russia in the 1950's--the Cold War--newer and larger bases were built near Fairbanks, Big Delta, Anchorage, and Kodiak to accomodate long-range bombers and fighters which were armed with nuclear weapons.

The Distant Early Warning (DEW Line) was constructed to warn of an invasion from the Soviet Union. These facilities included radar stations which were located along the northernmost frontier of the Arctic. They were linked together, and to the main defense centers, by the sophisticated White Alice communication system.

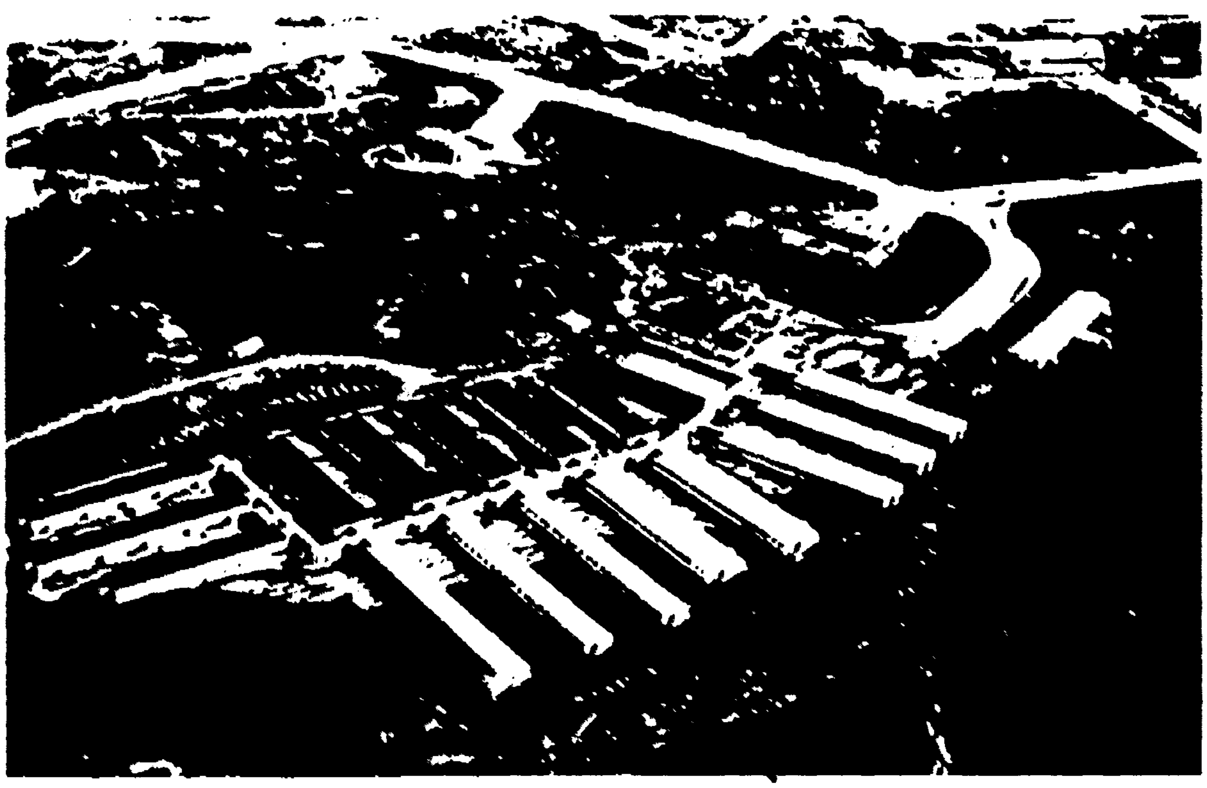


Ballistic missile early warning site at Clear Air Force Station in central Alaska, 1960.

Each technological advance of the military in Alaska marked a new construction boom. A peak of 300,000 military personnel was reached during World War II. In 1969 there were almost twice as many military personnel in Alaska than the total of all workers in farming, forestry, fishing, mining, oil and gas, construction, and manufacturing. In 1983, there were about 30,000 military personnel in Alaska.

Alaska Enters the Atomic Age: Project Chariot

In 1958, the Atomic Energy Commission (AEC) proposed to test atomic bombs in the Cape Thompson area of Alaska. As an economic incentive to Alaksans, the AEC proposed to use an atomic explosion to create a deep-water port for the extraction of minerals in the North Slope region. The project was known as "Project Chariot."



Base camp for testing the atomic bomb on Amchitka Island, September 1969.

Page One in '58 much like today

Statehood was the Page One story in Alaska during most of 1958, but the rest of the news was remarkably like what you would read today.

A big issue in both the Anchorage and Fairbanks papers was the construction projects at military bases near the two cities. The early June forest fires in the Interior also captured the front pages for several days, and a fire that threatened the village of Metlakatla was a major concern throughout the state.

In Fairbanks, the House debate in May shared front page space with a murder trial involving a bar room slaying. In June the Senate debate gave way to concern for a missing aircraft with four local residents aboard.

Sports fans can place the passage of the Statehood Act in the House by noting that sports pages were more interested in a 23-year-old rookie driver in the Indianapolis 500 named A.J. Foyt.

Both the space age and the Alaska oil boom were in their infancy in 1958. News stories noted that the Soviet Union had launched its third sputnik, and there was quite a bit of column space devoted to what federal royalties should apply to Alaskan oil in light of the recent discoveries on the Kenai Peninsula.

Nuclear disarmament was just as much in the news then as it is now, however. On May 12, 1958, Alaska's Delegate Bob Bartlett proposed the McKinley Park Hotel as the site of an upcoming summit meeting.

Bartlett noted that Alaska was midway between the two capitals on the shortest air route, and provided an ideal location for talks between the U.S. and the USSR

In 1962, after spending $3 million to promote the project and to fund initial research, the AEC abandoned the idea. Under vigorous protest, from within and outside Alaska, the AEC performed test firings of atomic bombs on Amchitka Island in the Aleutians. Underground blasts were set off in 1965, 1969, and 1971. The atomic blast of 1971 created a lake which was 55 feet deep and a mile and a half wide. In 1973, the AEC announced that no more testing would be performed in the area.

Most suggestions for building nuclear power plants in Alaska have been met with stiff oppostion from Alaskans.

Nuke-free Arctic sought

By CHARLES CAMPBELL
Associated Press Writer

FROBISHER BAY, Northwest Territories — Western Eskimo leaders, fearing their lands would become "a highway to hell," are demanding a ban on nuclear testing, energy plants, missiles and waste dumps in the Arctic.

The resolution for a nuclear-free Arctic passed unanimously Friday at the third General Assembly of the Inuit Circumpolar Conference. Inuit is the term many Eskimos prefer to call themselves. It means "the people" in Inuktituk, their native tongue.

Representatives from Greenland Canada and Alaska met at the conference. The Soviet Union refused to let any of its Siberian Eskimos attend.

The resolution urged Canada to reverse its decision to allow testing of U.S. cruise missiles "in our Canadian homeland."

It also opposed "placement of the MX missile in our Alaskan homeland," proposed installations of Canadian nuclear reactors in the Arctic and sub-Arctic and use of the region as a nuclear dump site.

JUNEAU EMPIRE, MONDAY, JULY 25, 1983

Developers and Conservationists

The controversy over project Chariot and the atomic blasts in the Aleutians divided Alaskans. At one extreme were the conservationists, who wanted to preserve the land in its natural state. At the other extreme were the developers, who wanted to develop the land and its resources. Most Alaskans found themselves somewhere between these two extremes.

Development in Alaska continues to

provoke heated debates, and will likely continue to do so for a long time to come.

"Yukon Power for America"

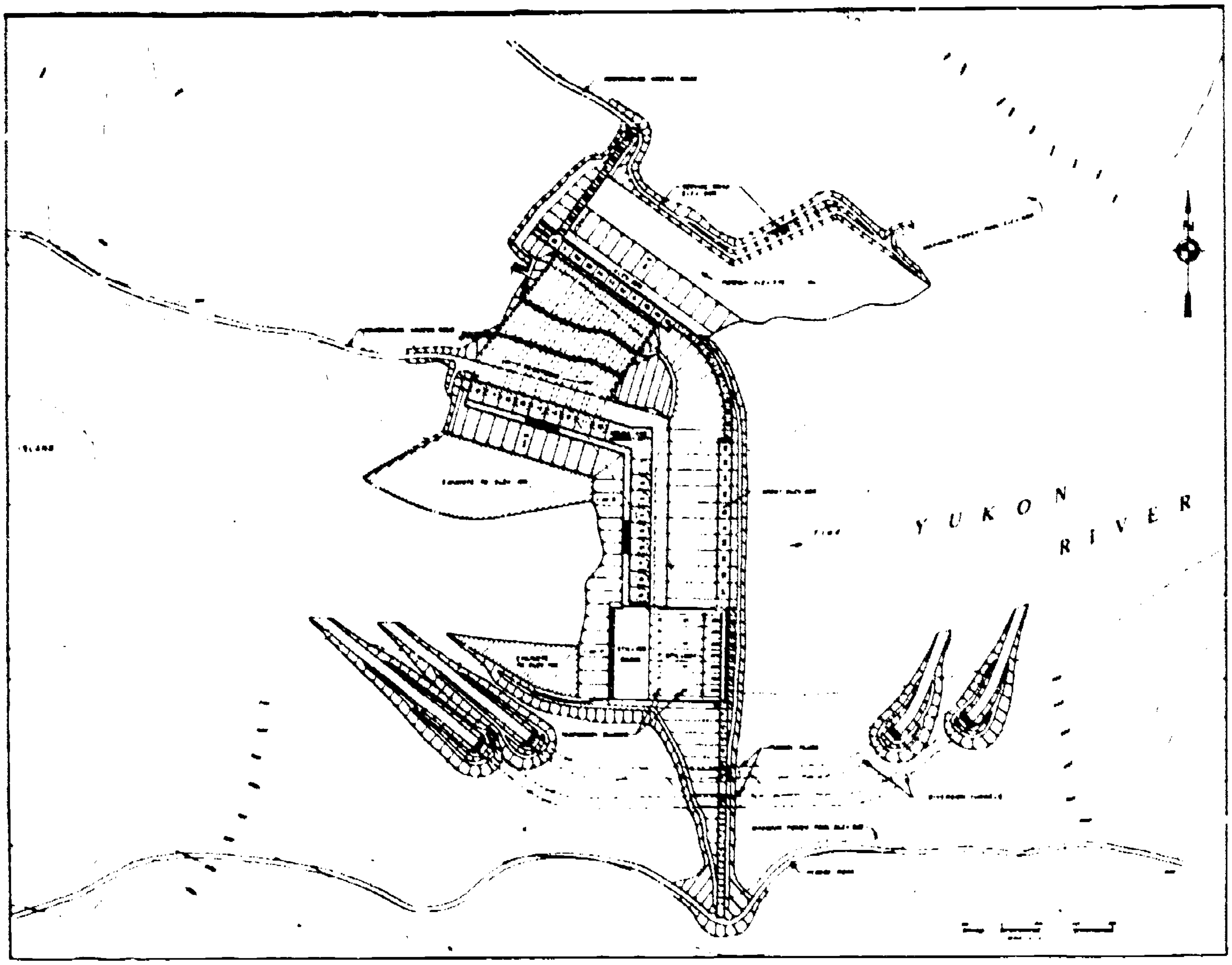
The debate over another proposed construction project drove the wedge between conservationists and developers still deeper. The U.S. Army Corps of Engineers proposed to build a huge dam on the Yukon River.

The project was supported by an organization of Alaskan businessmen, by newspapers, and by city mayors under the banner "Yukon Power for America." The dam would have been the largest in the world. The Rampart Dam, as it was to be called, was eventually put aside for a variety of reasons. These included unfavorable ecological and economic reports.

HYDROPOWER

Hydroelectric projects on a much smaller scale have been developed in Alaska, such as the Snettisham Project which provides most of the electricity used in Juneau.

A recently proposed five billion dollar hydroelectric project for the Susitna River has caused controversy in Alaska. As of 1983, there is still much debate about this project, especially over funding. As originally proposed, the state government would cover most of the intial cost of construction. There are also environmental and economic concerns.



A concept of Rampart Dam and hydroelectric plant

Oil: Black Gold

In recent times, by far the greatest impact on all aspects of life in Alaska has been the development of our huge oil resource.

As the supply of oil in the world has been depleted, and as political tensions have caused the United States and Europe to rely on sources of oil which are not dependable, the industrialized countries of the West have sought to develop their own resources. For Europe, this has meant developing the North Sea oil-fields of Great Britain and Norway. For the

United States, Alaska has figured prominently in national energy strategies.

There is one simple, overiding reason why both of these sources of oil had not been developed sooner--the price of oil was so cheap that the cost of extracting and shipping oil from Alaska and the North Sea was too great. The "Oil Crises" of 1973 and 1979 raised the price of a barrel of oil from $2 to about $30. The result? Alaska was on its way to an economic boom.

OIL

In 1982, more than 1.5 million barrels--63,000,000 gallons--of oil per day was pumped through the 800-mile-long pipeline, from oil-fields near Prudhoe Bay to Valdez on Prince Williams Sound. Approximately 100,000 additional barrels per day were extracted from the Cook Inlet area.

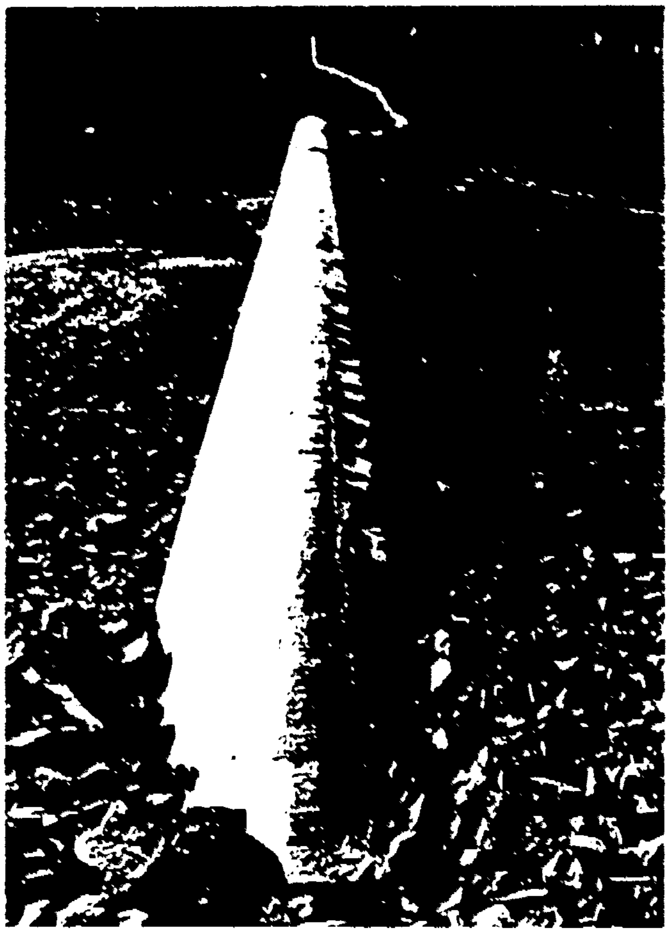
Using a very conservative (low) estimate of $15.00 per barrel, the value of Alaskan oil pumped in 1982 was $24 million per day, which amounts to almost $9 billion per year. For a population of 440,000 people, this is equivalent to $19,909.09 per person per year.

Obviously, the oil industry has become the largest source of income in Alaska. Oil income provided, in 1982, over 95% of the revenues received by the state government. In turn, the state government was the largest single employer in Alaska. The state government also provides money to local communities.

In January of 1983, 44,800 workers, of a total workforce of 191,900 (not including agriculture or commercial fishing) worked for either the state or local governments. An additional 18,000

were employed by the federal government. Many of the other workers depended on providing services to governmental workers for their livelihood. Very few Alaskans are actually employed by the oil industry.

In the second part of this course we will discuss the oil, natural gas, and coal industries in more detail.



Alaska

Three billion barrels of oil through pipeline

ANCHORAGE — The three-billionth barrel of crude oil to move through the trans-Alaska oil pipeline reached the marine terminal at Valdez on Thursday and was shipped south on the tanker ARCO Spirit.

Kay Herring of Alyeska Pipeline Service Co. said the landmark barrel reached Valdez at 9:26 a.m. on Thursday after 5 days and 10 hours in transit from the North Slope through the 800-mile pipeline.

The pipeline brings about 1.6 million barrels of North Slope crude to Valdez each day, including 1.5 million barrels from Prudhoe Bay and 100,000 barrels from the Kuparuk field.

The first North Slope crude was injected into the line on June 20, 1977, and the first oil was shipped from Valdez Aug. 1, 1977, on the ARCO Juneau.

Since then, more than 3,700 tankers have headed for refineries in the Lower 48 carrying North Slope crude.

JUNEAU EMPIRE, MONDAY, AUGUST 1, 1983

Infrastructure and Economic Diversification

As the quotation at the beginning of this lesson indicates, there has been a strong push in Alaska to use our oil wealth--which will eventually run out--to develop an economy in Alaska which can be sustained.

To do so, an attempt is being made to use the oil wealth to create a solid economic infrastructure--which would require transportation systems, agricultural systems, loan programs, etc.

Also, to use a phrase you learned in Lesson #4 of this chapter, *economic diversification* has become an important goal. The thrust of this approach is to create a large variety of businesses in Alaska, to lessen our dependence on businesses which are outside of Alaska, to provide jobs for Alaskans, and to keep our money within the state. The ultimate goal is to have an economy that won't collapse when the oil runs out.

TOURISM

Tourism is an industry which has helped to broaden Alaska's source of income. Hundreds of thousands of tourists are drawn to Alaska every year. They spend an estimated $300 million, over and above their travel costs to and from the state.

Two Key Problems: Transportation and Manufacturing

For a vigorous, sustainable, independent Alaskan economy, it would be necessary to manufacture products which are used within the state. It is also necessary to transport those and other products to the people who need them.

In January of 1983, there were only 7200 people employed in manufacturing industries in Alaska. Most of these people were involved in the lumber, paper, or food industries. Why so few?

To answer this question, it is important to know what is necessary for a manufacturing industry to be ***competitive***--able to compete with other industries. In Alaska, transportation is costly and wages are high. Also, there is a very small market--not many buyers. For almost all products which we use in Alaska, it is usually cheaper

to import them from outside of the state than to manufacture them here.

Transportation is a problem, also. Currently, about 45% of the energy used in Alaska is expended on transportation. Roads which connect our dispersed population are expensive to build and to maintain. Rail transport is not yet extensive, while we rely heavily on energy-intensive air transport. Transport by sea is one of the most cost-effective means of transportation for Alaska. In general, transportation is costly for Alaskans.

Most of the drive for economic diversification has been aimed at the development of natural resource export industries: timber, fisheries, natural gas, coal, and other minerals.

TRANSPORTATION

In 1977, about 2.6 million tons of goods were imported into Alaska. Of this total, about 1.8 went to Anchorage and Fairbanks.

Also in 1977, about 21.1 million tons of goods were shipped from Alaska. Of this total, about 10.2 million tons was oil leaving Valdez. The amount of oil shipped from Alaska has increased substantially in recent years.

**A Curious Thought:
Manufacturing and Automation**

Recent advances in automation technologies can be projected into the future to raise some interesting possibilities.

Let's suppose that we want to make chainsaws in Alaska. Currently, many of the requirements for a competive

chainsaw industry don't exist in Alaska--such as a cheap source of special steel alloys, a plastics industry, and a source of *manufacturing experts*.

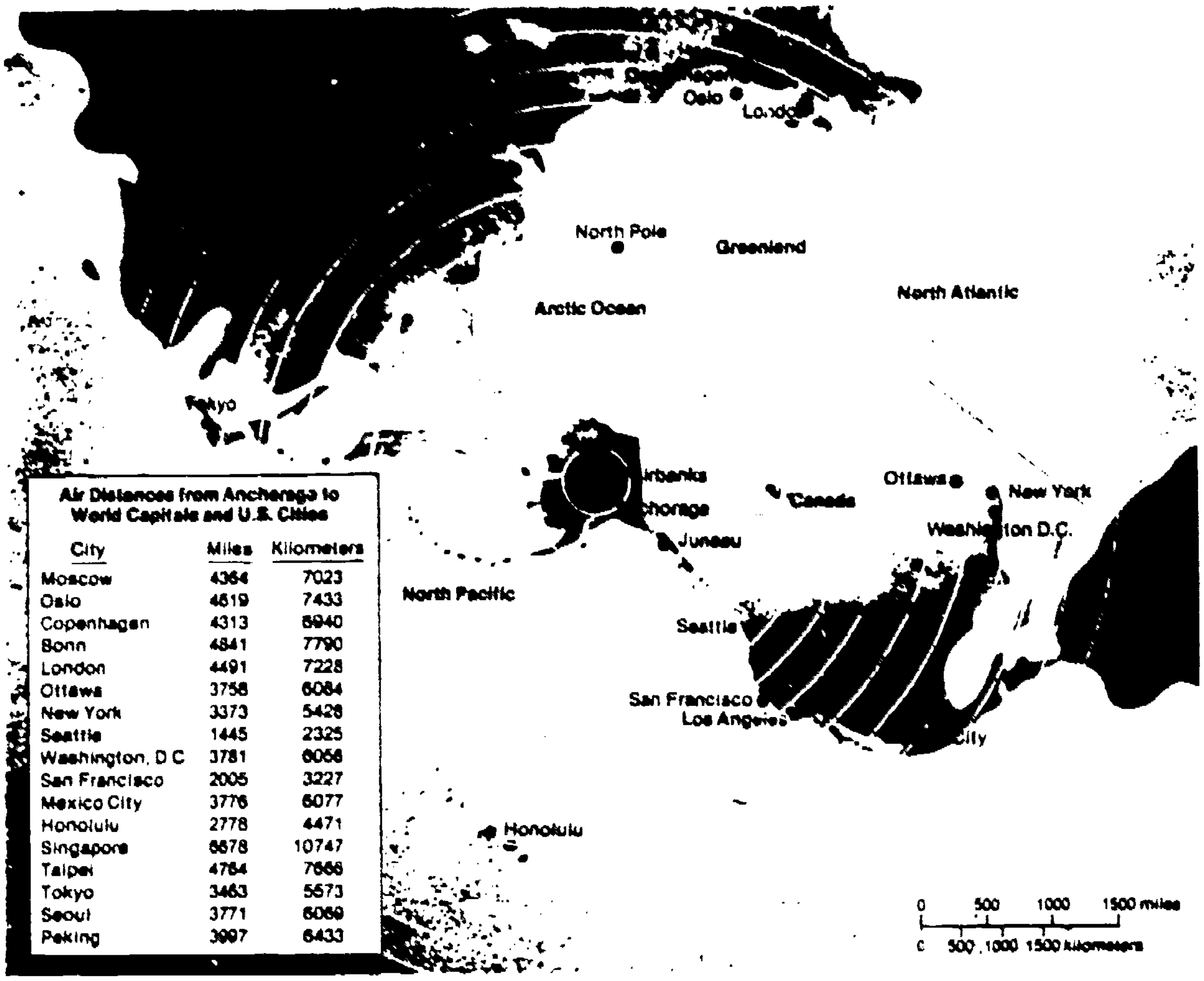
But what if we had a robot and software (the computer program) which could make and repair chainsaws? Maybe the manufacturing factories of the future will be small shops with robots that can make many, many products from a standard supply of materials. These materials can be made from natural resources found in Alaska.

This might sound like unrealistic science fiction, but the possibility is real. Now is the time to start thinking and planning for the future. Most importantly, we in Alaska need to ask of ourselves: "What kinds of technologies and lifestyles do we want? What actions must we take to prepare for the future?"

The Irony of History

We began this lesson with the Japanese invasion of the Aleutian Islands, which in turn plunged Alaska into the modern technological world almost overnight. As a curious irony, today the Japanese play an enormous role in Alaska's economy. The Japanese own or control much of the fishing and lumber industries in Alaska. Japan is the final destination of many goods shipped from Alaska. Many of the manufactured products bought by Alaskans originate in Japan.

In 1973, when the Transalaska pipeline was being debated in the halls of the State Legislature, many people claimed that the oil was too expensive to ship to the continental United States, and that Japan was the most economically feasible place to sell it. In 1983 the issue of selling Alaskan oil



Air Distances from Anchorage to World Capitals and U.S. Cities

City	Miles	Kilometers
Moscow	4364	7023
Oslo	4619	7433
Copenhagen	4313	6940
Bonn	4841	7790
London	4491	7228
Ottawa	3758	6084
New York	3373	5428
Seattle	1445	2325
Washington, D C	3781	6068
San Francisco	2005	3227
Mexico City	3776	6077
Honolulu	2778	4471
Singapore	6678	10747
Taipei	4764	7666
Tokyo	3463	5573
Seoul	3771	6069
Peking	3997	6433

ALASKA: HOLDING CENTER STAGE IN A WORLD OF TRADE.

Alaska lies at the center of a trade hemisphere that stretches from Europe to the Orient, as well as to Canada and the Lower 48 states. Anchorage's International Airport—one of the world's busiest—is located almost midway between New York and Seoul, Bonn and Peking, London and Taipei. Alaska's deep, ice-free ports are closer to trade centers of the Northern Pacific Rim than are any other ports in North America.

Some industries and businesses have already recognized the importance of this world-central position. Many have established corporate headquarters in Alaska, others use the state as a transfer and warehouse point in international trade. And some bring raw materials to Alaska for processing and reshipment to other markets.

to Japan was raised once again as a serious possibility.

Perhaps Alaska's economic future will entail more and more trade with Japan and other Pacific Rim Countries. Korea buys Alaskan coal and is expected to buy large quantities of Alaskan barley. Alaskans are giving serious

attention to trade with People's Republic of China.

It is very likely that the immediate and long-term future of Alaska's economy will be intimately tied to international trading. This trade is likely to consist of the exporting of raw materials and the importing of manufactured products.

Whether or not this type of economic development is the best choice for Alaskans and for our trading partners is a question with no simple answer. Advantages and disadvantages are both numerous. The road along which we will travel into the future could lead to many places.

What do we want in Alaska?

In Alaska we are fortunate. We are fortunate because we have much to choose from. We are a small population in an enormous land both beautiful and rich. It is up to us to decide what we will do with these gifts.

In *Part II* of this course we discuss choices--choices of technologies for Alaska's future.

COMPLETE THE FOLLOWING WORKSHEET.

A HISTORY OF TECHNOLOGY

WORKSHEET

Describe the types of development that you would like to see take place in Alaska *during the next 100 years*. Carefully explain the benefits and the costs of these developments.

Discuss both *ideal* and *pragmatic* concerns. Be sure to consider market forces and government participation. Keep in mind the infrastructural needs for what you propose.

This worksheet might seem to be a repeat of questions which you have already answered--but you now have much more information with which to work. Try to pull together what you have learned in previous lessons. Here are some suggested methods for writing:

1) Just start writing! This method works well for some people.

2) Write what first comes to mind. Review what you have written and then carefully rewrite a final version.

3) Review all of your worksheets from previous lessons. Write down any thoughts that come to mind. Put these thoughts into the order in which you want to write about them. Make an outline of what you want to write. Gather all of the information which you want to include. Write. Rewrite. Add an introduction and a concluding statement.